I25

OPERATING AND SERVICE MANUAL

DIGITAL VOLTAGE SOURCE

MODEL 6131C

BCD LOGIC

HEWLETT PACKARD

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

DIGITAL VOLTAGE SOURCE
MODEL 6131C
BCD LOGIC

OPERATING AND SERVICE MANUAL

FOR SERIALS 1312A-00101 AND ABOVE*

*For Serials Above 1312A-00101
a change page may be
included.

Hewlett-Packard

HP Part No. 06131-90005

Printed: January, 1974

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Digital Voltage Source (DVS) is a complete digital-to-analog link between a computer (or other digital source) and any application requiring a fast accurately settable source of dc or low frequency ac power.

1-3 A constant voltage/current limiting source, the DVS will furnish full rated output voltage at the maximum rated output current or can be continuously programmed throughout two output voltage ranges. The output is bipolar, and is programmable on either side of, or through, zero without output polarity switches or "notch" effects. In addition, the DVS has low output impedance—the load does not degrade the accuracy specification. The DVS analog output is floating and fully isolated from the digital inputs, thus avoiding ground loops between the output ground and the computer ground.

1-4 The output voltage is controlled by digital data inputs applied to the DVS via a ribbon connector on the rear panel.

1-5 Overcurrent protection is provided by a current "latch" circuit which can be externally programmed to one of six values between 4% and 100% of the units rated output current. When activated, the current latch circuit turns off the output power amplifier reducing the output current to less than 10mA. The reaction time of the current latch circuit (time between the start of a current overload and turn off of the power amplifier) can be adjusted by adding an external capacitor at the rear terminals. The upper current limit is safeguarded by a separate fixed current limit circuit that prevents the output current from exceeding 110% of the current rating. The computer is continuously informed of possible current overload or current latch conditions by status outputs which are fed back to the user's source.

1-6 For maximum reliability and minimum size and weight, the DVS utilizes all solid state circuitry. Most of the DVS circuitry is contained on five removable plug-in circuit boards, accessible from the front of the unit through an access door.

1-7 Output voltage and current are continuously displayed on two front panel meters. The front panel METER RANGE switches select the desired voltmeter and current meter ranges.

1-8 The DVS also limits sink current (resulting from an active load forcing energy back into the DVS) to a value between 0.25A and 0.55A as a function of sink voltage magnitude.

1-9 Terminals for High Output, High Sensing, Low Output, Low Sensing, Chassis Ground, Current Latch Delay, Analog Input, and Current Monitor are included on a rear barrier strip. The Low Output terminal may be connected to the ground terminal, or the output may be floated up to 300 volts above ground. The output terminals are automatically shorted if the digital input cable is disconnected or if the input power is removed. The Sensing terminals may be used when the load is remotely located from the DVS in order to minimize degradation in regulation at the load due to voltage drop in the load leads.

1-10 INTERFACING

1-11 Each DVS is pre-interfaced with its controlling computer, or other digital device, by modifying four of the plug-in boards. Five standard sets of these boards (Option J20 and Options 061 through 064) satisfy the majority of interfacing requirements. Each instrument must have either an Option number or a "Special" modification number (e.g., J01, J02, etc.) for identification. The Jxx numbers are used for instruments which do not fit into the standard option category. Detailed descriptions of the different options are included in Appendixes at the rear of each manual while descriptions of special options are included on blue modification sheets in the front of applicable manuals. The option number for each instrument appears on an identification tag at the rear of the unit.

1-12 As supplied from the factory, the DVS can be operated from a 115Vac ±10%, 48-440Hz power source. In addition, the DVS can be operated from a 230Vac ±10% single phase input when the unit is equipped with Option 28 (see Paragraph 1-15). This versatility makes the instrument compatible with the European power system.

1-13 SPECIFICATIONS

1-14 Complete specifications for the Digital Volt-

age Source are given in Table 1-1.

1-15 OPTIONS

1-16 As mentioned previously all DVS's are pre-interfaced at the factory. There is no standard instrument; each unit has an option number for identification. There are five "standard" options which satisfy the majority of interfacing requirements. Two of these options (061 and 063) are for BCD instruments while the other three (J20, 062, and 064) are for binary units. Detailed coverage of these options is included in Appendixes at the rear of the manual.

Option No.	Description
028	Rewire for 230Vac Input: Consists of reconnecting the input transformers for 230 volt operation and changing the fuse. (Refer to Section II for details.)
J20	Binary Interface for hp 12661A DVS Program Card: Input/output circuits on P.C. boards A1, A2 and A6 are modified to interface with hp computer. (Refer to proper Appendix for details.)
061	BCD Interface for NPN Open Collector Circuits: Input/output circuits on P.C. boards A1, A2 and A6 are modified to interface with a BCD digital source employing "open collector" drivers. (Refer to proper Appendix for details.)
062	Binary Interface for NPN Open Collector Circuits: Input/output circuits on P.C. boards A1, A2, and A6 are modified to interface with a binary source employing "open collector" drivers. (Refer to proper Appendix for details.)
063	BCD Interface for Microcircuit Logic Levels: Input/output circuits on P.C. boards A1, A2, and A6 are modified to interface with a BCD source employing microcircuit logic of the TTL or DTL family. (Refer to proper Appendix for details.)
064	Binary Interface for Microcircuit Logic Levels: Input/output circuits on P.C. boards A1, A2, and A6 are modified to interface with a binary source employing microcircuit logic of the TTL or DTL family. (Refer to proper Appendix for details.)

1-17 INSTRUMENT IDENTIFICATION

1-18 Hewlett-Packard instruments are identified by a three-part serial number. The first part is the power supply model number. The second part is the serial number prefix, consisting of a number-letter combination denoting the date of a significant design change. The first digits indicate the year (10 = 1970, 11 = 1971, etc.); the second two digits indicate the week; and the letter "A" designates the U.S.A. as the country of manufacturer. The third part is the power supply serial number; a different 5-digit sequential number is assigned to each power supply, starting with 00101.

1-19 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes define the differences between your instrument and the instrument described by this manual.

1-20 ORDERING ADDITIONAL MANUALS

1-21 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP Part number shown on the title page.

Table 1-1. Specifications

INPUT AND OUTPUT POWER

Input:

115Vac ±10%, 48-440Hz, 1.2A, 100W (Standard)

230Vac ±10%, 48-440Hz, 0.6A, 100W (Option 28 only)

Output:

X1 Range: -9.999 to +9.999Vdc @ 0.5A Source.

X10 Range: -99.99 to +99.99Vdc @ 0.5A Source.

Sink Current Compliance.

A sink condition results from an active load attempting to force energy back into the DVS. This can appear as current flow into the HI output terminal when the terminal is positive, or current flow out of the terminal when it is negative. In either case the current is limited to a value ranging linearly from 0.25A at 100V to 0.55A at 0V.

ACCURACY

Basic Accuracy:

DC voltage accuracy at 23°C ± 3°C, 115Vac input, no load, following 30 minutes warm-up.

X1 Range: 1mV
X10 Range: 10mV

Source Effect (Line Regulation):

Change in output voltage for any change in line voltage from 104 to 126Vac (or 208 to 254V ac).

X1 Range: 400μV
X10 Range: 4mV.

Load Effect (Load Regulation):

Change in output voltage for any change in load current within rating.

X1 Range: 150μV
X10 Range: 500μV

Temperature Coefficient:

Change in output voltage per degree Centigrade change in ambient temperature.

X1 Range: 100μV/°C
X10 Range: 1mV/°C

PERIODIC AND RANDOM VOLTAGE DEVIATIONS

Drift (Stability):

DC output voltage drift under constant line, load, and ambient temperature for 8 hours after 30 minutes warm-up.

X1 Range: 300μV
X10 Range: 3mV

PARD (Ripple and Noise):

p-p/rms (dc to 50MHz), at any line voltage and under any load condition within rating.

X1 Range: 2mV p-p/0.5mV rms
X10 Range: 7mV p-p/ 1.5mV rms

Load Transient Recovery Time:

Time required for the output voltage to recover within 0.1% of full range voltage following a full load current change.

X1 or X10 Range: 150μsec.

SPEED

Programming Time:

Maximum time required for the output voltage to settle within 0.1% of the programmed voltage change after simultaneous receipt of data and gate signals with a resistive load connected across the output terminals.

X1 or X10 Range: 300μsec. Voltage range change requires 2msec.

ANALOG INPUT

Impedance: 10kΩ ±.1%.

Maximum Input Voltage (Full Range):

X1 Range: ±20V
X10 Range: ±10V

Bandwidth (to -3dB Point): Approx. 25kHz.

DC Gain: X1 Range: -1 ±0.2%
X10 Range: -10 ±0.2%.

Stability (8 hours):

X1 Range: Same as stability of input signal + 500μV.

X10 Range: Same as stability of input signal + 5mV.

CURRENT SENSING

Impedance: 800Ω

Coefficient: 1 Volt/Amp.

Accuracy: 3% ±2mA

TEMPERATURE RATINGS

Operating: 0°C to + 55°C.

Storage: -40°C to + 75°C.

COOLING

Convection cooling is employed.

ACCESSORIES FURNISHED

50-Contact Rear Plug, HP Part No. 1251-0086.
Rack Mounting Kit, HP Part No. 5060-8740
Plug-In Extender Board, HP Part No. 5060-7948

ACCESSORIES AVAILABLE

Pocket Programmer, Model 14533B. This accessory permits manual programming of all input functions by switch closures.

3-Foot Extension Cable for Pocket Programming, Model 14534A. This accessory may be used with the Pocket Programmer for maximum convenience.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is received, proceed as instructed in the following paragraphs.

2-3 MECHANICAL CHECK

2-4 If external damage to the shipping carton is evident, ask the carrier's agent to be present when the instrument is unpacked. Check the instrument for external damage such as broken controls or connectors, and dents or scratches on the panel surfaces. If the instrument is damaged, file a claim with the carrier's agent and notify Hewlett-Packard Sales and Service Office as soon as possible. If the instrument appears undamaged, perform the electrical check given in the following paragraph.

2-5 ELECTRICAL CHECK

2-6 Check the electrical performance of the instrument as soon as possible after receipt. Section V of this manual contains performance check procedures which will verify instrument operation within the specifications stated in Table 1-1. This check is also suitable for incoming quality control inspection. Refer to the inside front cover of the manual for the Certification and Warranty statements.

2-7 REPACKING FOR SHIPMENT

2-8 When shipping the entire instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument specifying the owner, model number, full serial number, and service required, or a brief description of the trouble.

2-9 INSTALLATION DATA

2-10 The instrument is shipped ready for bench operation. Power connections are made through the power cable supplied with the unit. The digital inputs to control the output voltage, current limit, etc., must be supplied through the data input plug (P1) at the rear of the unit. Section III of this manual provides a complete description of the interfacing requirements.

2-11 LOCATION

2-12 This instrument is convection cooled. Sufficient space should be allotted so that a free flow of air can reach the rear of the instrument when it is in operation. It should be used in an area where the ambient temperature remains between $0^{o}C$ and $+55^{o}C$.

2-13 OUTLINE DIAGRAM

2-14 Figure 2-1 shows the outline and dimension information for the instrument which can be used to plan a specific installation.

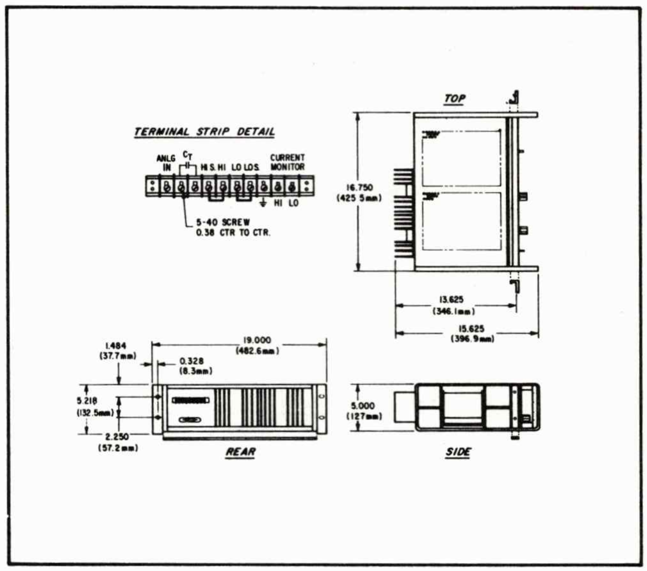


Figure 2-1. Outline Diagram

2-15 RACK MOUNTING

2-16 To mount the unit in a standard rack panel, proceed as follows:

a. Remove gray plastic trim strips (glued on) at each side of unit by inserting a thin screwdriver

at edge or top of strip and prying gently away from unit.

b. Attach rack ears (furnished with each unit) to side of unit using screws supplied with ears.

c. Mount unit in rack, using standard mounting screws.

2-17 INPUT POWER REQUIREMENTS

2-18 POWER REQUIREMENTS

2-19 This instrument may be operated continuously from either a nominal 115 volt or 230 volt, 48-440Hz power source. The unit as shipped from the factory is wired for 115 volt operation. The input power required when operated from a 115 volt power source at full load is 1.2 amperes, 100 watts.

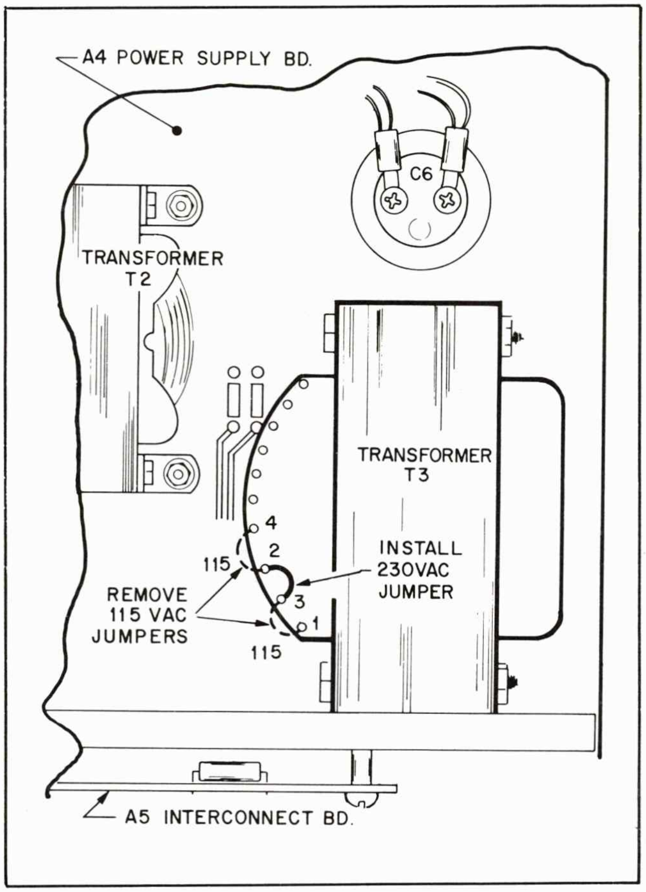


Figure 2-2. Primary Connection for 230Vac Operation

2-20 CONNECTIONS FOR 230 VOLT OPERATION (Figure 2-2)

2-21 Normally, the primary windings of input transformers T2 and T3 are connected in parallel for operation from a 115 volt source. To convert the unit to operate from a 230 volt source, the primary windings of each transformer must be connected in series as follows:

a. Unplug line cord and remove top cover.

b. Looking from the rear of unit, locate the 115Vac jumpers between terminals 1,3, and 2,4 of transformer T3 (see Figure 2-2).

c. Remove both 115Vac jumpers and solder the 230Vac jumper between terminals 2 and 3 of transformer T3 as shown in Figure 2-2.

d. Replace existing fuse (on rear panel) with 1 ampere, 230V fuse.

2-22 POWER CABLE

2-23 To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable's three prong connector is the ground connection.

2-24 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the ground lead on the adapter to ground.

SECTION III
OPERATING INSTRUCTIONS

Figure 3-1. Model 6131C, Rear View

3-1 DATA INPUT CONNECTOR

3-2 Before output voltage can be obtained, data input plug P1 must be in place as shown in Figure 3-1. A connection must be made between the cable continuity interlock pin 25 and the computer common (relay A4K1 must be energized; see Figure 7-2, Sheet 3). If this connection is not present or if the input connector is removed, the output terminals will be shorted and the output current will be reduced to less than 10mA. This protects any loads connected to the DVS in the event that the cable is inadvertently disconnected. Note also that the output is shorted when ac power is removed.

3-3 AC INPUT

3-4 To turn on the unit, set the LINE switch (item 1 in Figure 3-2) to ON. The pilot light directly above the LINE switch should light. Fuse 1 (2A at 115Vac or 1A at 230Vac) protects the main power supply.

NOTE

Any deflection of the current meter after turn-off does not represent current flowing in the load but rather is current flowing through the internal shorting relay.

3-5 VOLTMETER RANGES

3-6 The VOLTAGE control ② selects either the 120V or 20V meter range, which corresponds to the upper and lower scales on the voltmeter. The shaded area on the front panel meter face indicates the amount of output voltage that is available in excess of the normal rated output. Although the instrument will operate in this shaded region without being damaged, it is not guaranteed to meet all of its performance specifications.

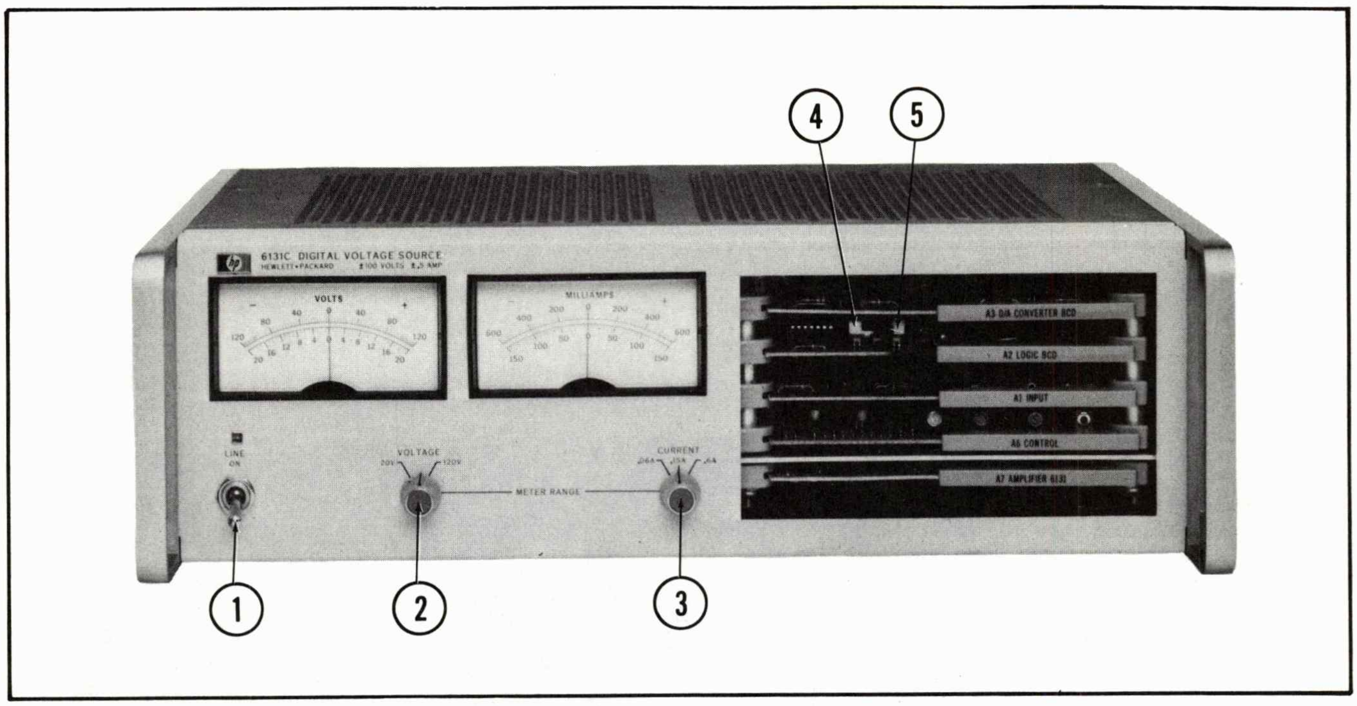


Figure 3-2. Operating Controls and Indicators

3-7 AMMETER RANGES

3-8 The CURRENT control, ③ selects the current range on the front panel meter, 0. 06, 0. 15, or 0. 6A. A 2-amp slo-blo fuse is used as shown on the rear of the unit.

3-9 PROGRAMMING

3-10 Input/output data is connected from a digital computer to P1/J1 on the rear of the DVS as shown in Figure 3-3. A substitute for the computer is the HP Pocket Programmer. This accessory plugs into J1 and manually programs all of the input to the DVS by switch closures. An extension cable, with connectors on both ends, is also available to mate with J1 and the Programmer plug. Pocket Programmers can be purchased from your local Hewlett-Packard Sales Office.

3-11 The coding, voltage levels, and polarity of the input/output data are selected by the customer to fit his application. Four plug-in boards, A1 Input, A2 Logic, A3 D/A and A6 Control, are modified at the factory to fit these requirements. Most customer requirements can be satisfied by one of the standard options for this instrument. For requirements beyond the scope of the standard options, special modifications are made to the A1, A2, and A6 boards. Either an option number or a special (J) number is assigned to each instrument and is printed on an identification tag on the rear heat sink of the unit. Options are described in Appendixes located at the rear of the manual while specials changes are described in an "Instrument

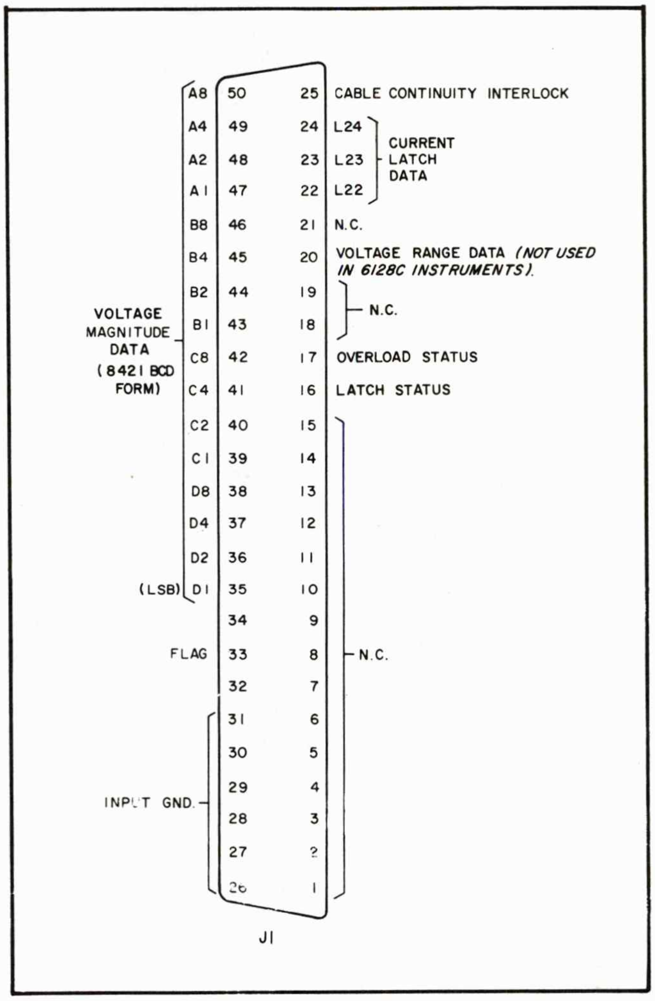


Figure 3-3. Input/Output Data Connector

Modification" sheet which is inserted in the front of any applicable manual.

3-12 The following paragraphs describe the input/output data that is transferred between the computer and the DVS. Sufficient detail to operate the instrument is included; more detailed information is included in Section IV.

3-13 VOLTAGE MAGNITUDE AND VOLTAGE SIGN DATA INPUTS

CAUTION

When programming the output voltage, do not set the voltage magnitude bit switches (digits A through D) for codes greater than nine as some invalid codes will program the output voltage beyond the unit's rated maximum output voltage. When a positive output sign is programmed, an invalid current magnitude code will produce a negative output voltage.

3-14 Sixteen input data lines control the magnitude of the output voltage, four lines for each of four decimal digits. The four lines for each digit are coded in the 8-4-2-1 BCD code. The most significant digit is designated digit A, and its bits A8, A4, A2, and A1. Digits B, C, and D are coded similarly, with bit D1 the least significant bit. The logic state of the sign bit input determines the polarity of the output voltage.

3-15 The voltage magnitude and sign data are stored in the DVS upon the receipt of a gate input from the computer. As shown in Figure 3-4, the voltage magnitude and sign data bits must remain for at least 10μsec after the triggering edge of the Gate. Once the 10μsec period is expired, the voltage program and sign can be changed to prepare for the next gate. The gate must reset for at least 2μsec before starting a new gate, and the time between the leading edges of two consecutive gates must be at least 55μsec.

3-16 Notice that in addition to initiating the storage and processing of voltage and sign data, the Gate also stores the voltage range and current latch data which are discussed in subsequent paragraphs. It should be noted, though, that the trailing edge of the Flag indicates to the computer that the voltage processing is complete and will occur 55μsec after the leading edge of the Gate provided the voltage range of the DVS has not been changed. If a voltage range change is programmed, the trailing edge of the Flag is delayed to 2msec from the leading edge of the Gate (refer to Paragraph 3-21).

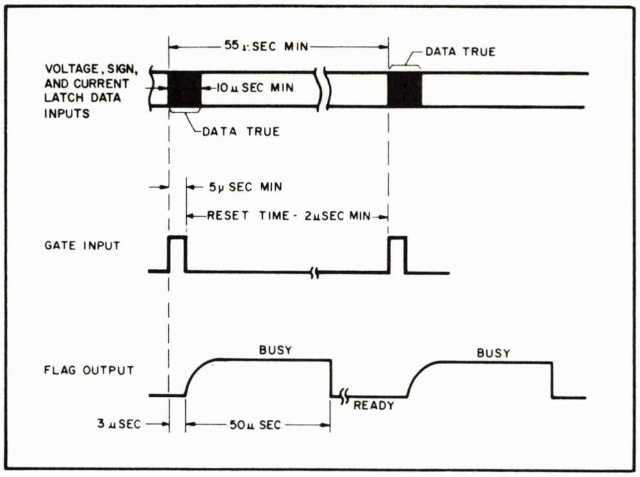


Figure 3-4. Timing Diagram, No Range Change

3-17 STORAGE

3-18 With the STORAGE switch ④ (Figure 3-2) in the STORE position, the voltage, sign, range, and current latch program data are stored when the gate is received from the computer. In the DISABLE position, indicator DS1 ⑤ lights and the data are processed as soon as they are received.

3-19 Storage can be disabled in cases where a manual programmer is used or where the computer has internal storage for the voltage magnitude and sign data.

3-20 VOLTAGE RANGE

3-21 The voltage range data input from the computer multiplies the voltage magnitude data X1 for the lower range or X10 for the higher range. In the X1 range, the maximum output voltage swing is from -9.999 to +9.999 volts. In the X10 range, the output voltage swing is from -100.00 to + 100.00 volts. The range of the DVS is controlled by the voltage range data bit from the computer which is stored (along with the voltage magnitude, sign, and current latch data) in the DVS when the Gate input is received. As shown in Figure 3-5, the voltage range data bit must remain for at least 10μsec after the triggering edge of the gate. Once the 10μsec period is expired the voltage range input can be removed. The gate must reset for at least 2μsec before starting a new gate, and the time between the leading edges of two consecutive gates must be at least 2msec.

3-22 If a range change is programmed, then, the trailing edge of the Flag sent to the computer is delayed 2msec after the leading edge of the Gate. If a range change is not programmed, the DVS Flag is returned 55μsec after the Gate as indicated in Figure 3-4 and discussed in paragraph 3-15.

3-23 Voltage Range Programming. The voltage range bit from the computer has two states, X1 and X10. In the X1 range, the voltage magnitude data input is multiplied by 1 so that the output voltage can be varied between 0.000 and 9.999 volts in 1mV or greater steps. In the X10 range, the voltage magnitude data input is multiplied by 10 so that the output voltage can be varied between 0.000 and 99.99 volts in steps of 10mV or greater.

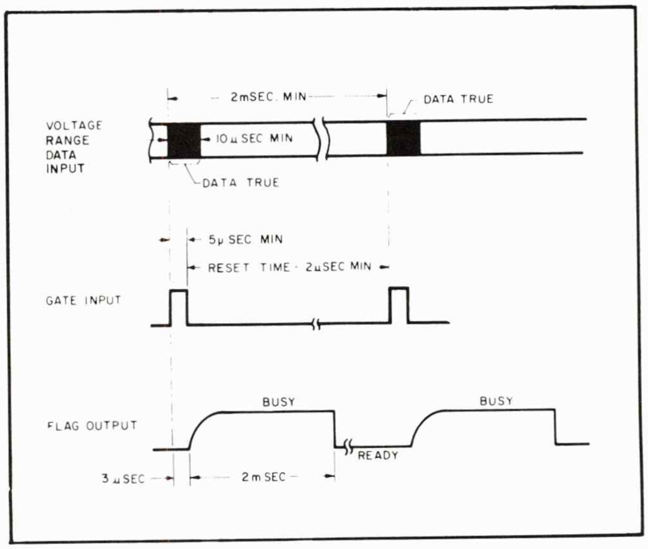


Figure 3-5. Timing Diagram, Range Change

3-24 CURRENT LIMIT

3-25 The DVS provides a maximum (gross) limit and a programmable current latch. Each is controlled independently by a separate circuit. controlled independently by a separate circuit. The gross current limit circuit is fixed to activate at approximately 110% of the rated output current (approximately 0.55A). The adjustable current latch circuit can be programmed to 20, 50, 70, 100, 200, and 500mA, Current latch input data consist of three lines: L22 (30mA), L23 (50mA), and L24 (range, X1 or X10). All three inputs are stored in the DVS when the gate signal is received. As shown in Figure 3-4, the current latch data must remain for at least 10µsec after the triggering edge of the gate. The flag signal is sent to the computer 55µsec after the gate to indicate that current latch processing is complete.

3-26 If the overload condition persists for a certain variable delay period, the current latch circuit is activated and the output current is reduced to from 0 to ±10mA, depending on the type of load connected to the unit. The output voltage, under current latch conditions, depends on the programmed output voltage and the type of load. With a full resistive load connected to the unit, the output voltage (and current) are reduced to nearly zero. At no load, the output voltage will correspond to the programmed voltage; up to a maximum of 40 volts. After the load current is reduced or the current latch increased, the next gate that is received will reset the current latch circuit and return the unit to normal operation.

3-27 In addition to the current limits described above, the current limit circuits also protect the DVS from active loads that force energy back into the DVS (sink condition). This can appear as current flow into the HI output terminal when the terminal is positive, or current flow out of the terminal when it is negative. Figure 3-6 shows the normal operating locus of the DVS. As shown, the DVS will limit the sink current to a value ranging linearly from 0.25A at 100V to 0.55A at 0V.

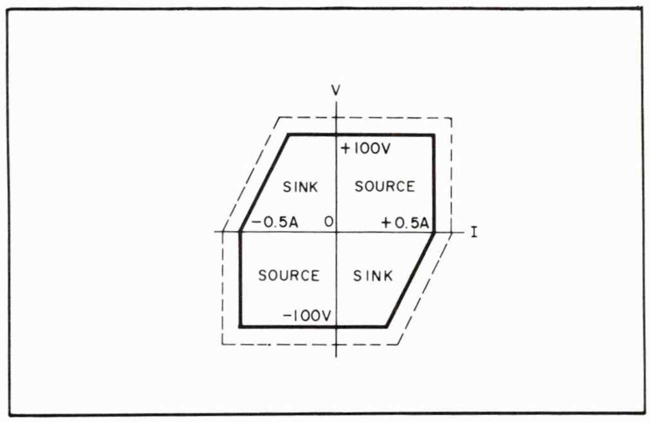


Figure 3-6. 6131C Output Ranges

CAUTION

Externally applied terminal -to- terminal voltage in excess of 110V will damage the DVS.

3-28 Current Latch Programming. The current latch data bits L22 (30mA), L23 (50mA), and L24 (range) from the computer form a 3-bit binary code to program the DVS current latch value. The states of the 30mA and 50mA bits determine the basic value; the state of the range bit multiplies that value by 1 or 10. The three current latch bits provide a maximum of eight possible combinations. As shown in the following chart, only six of the bit combinations are utilized (20, 50, 70, 100, 200 and 500mA) for Model 6131C. If the pocket programmer is used to program the current latch, refer to the associated manual.

3-29 CURRENT OVERLOAD AND LATCH

3-30 If the output current exceeds the value of the programmed current latch a 10µsec flag signal and the overload status signal are sent to the computer

CURRENT LATCH CODING

CURRENT LATCH (mA)	L24 (RANGE)	L23 (50mA)	L22 (30mA)
20	HI	HI	HI
50	HI	HI	LO
70	HI	LO	HI
100	HI	LO	LO
200	LO	HI	HI
500	LO	HI	LO

HI = more positive voltage
LO = more negative voltage

as shown in Figure 3-7. If the overload condition still exists after a variable delay period, (refer to next paragraph) the unit commences current latch operation and the latch status signal changes state. The current overload status signal switches to the normal state when the current latch mode commences. A second 10-μsec wide flag signal is produced when current latch begins.

NOTE

For standard Option J20, the two 10μsec Flag outputs corresponding to the leading and trailing edges of the Overload status output are disabled and not transmitted to the computer.

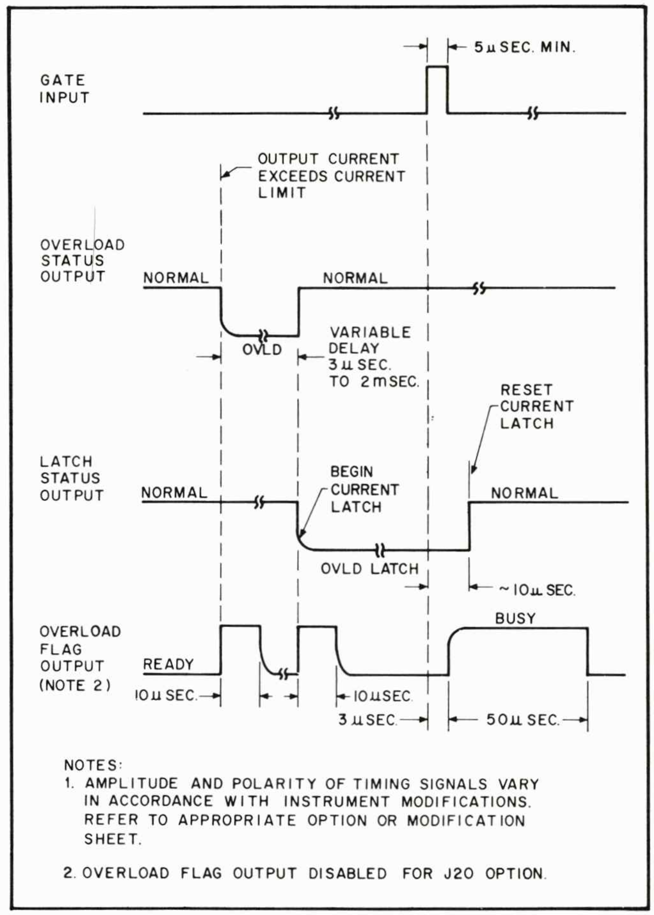


Figure 3-7. Current Latch Overload Timing Diagram

3-31 Current Latch Delay. Two terminals, C_T, on the rear barrier strip are provided for connection of a capacitor to delay the current latch circuit. Capacitor C_T determines the delay between detection of an over-current condition (current overload status) and the time that current latch begins (the current latch status signal switches to the overload state). Some delay is desirable when driving a capacitive load, since current surges higher than the current latch setting would activate the current latch circuitry. If the C_T terminals are open, a natural delay period of from 3 to 10μsec (approximate) will result. If capacitor C_T is utilized, the delay is adjustable between 5μsec and 2msec at the rate of approximately 1μF per msec.

3-32 The current latch status signal will switch from overload to normal state approximately 10μ sec after the next gate providing that the overload condition no longer exists. Therefore, to program the DVS out of the current latch condition and back to normal operation, the overload must be removed or the current latch increased; and then a new gate must be issued. The flag will switch to busy 5μsec after the gate is received and remain in that state for 50μsec.

3-33 Current Latch Disable. The current latch circuit within the DVS can be disabled by shorting the C_T terminals at the rear of the unit. Under these conditions, the current limit is governed solely by the gross current limit circuit which fixes the current limit at about 0.55 amperes. Although the current latch status signal is not generated, the overload status signal is switched to the overload state if the output current exceeds the programmed current latch value. Shorting the C_T terminals is useful during calibration or troubleshooting when it is desirable to keep the unit out of the current latch mode. Ensure that the shorting wire(s) across the C_T terminals is short (less than six inches long). The inductance of long wires could cause the current latch circuit to become activated.

3-34 Current Latch At Turn On. At turn on, the output terminals are shorted for approximately 0.2 second. This will activate the current latch circuitry reducing the output current accordingly. After the short is removed from the output terminals, a gate input must be received from the computer to reset the latch circuit and return the unit to normal operation.

3-35 CONNECTING THE LOAD

3-36 Low sense (LO. S.) and high sense (HI.S.) should be connected to LO and HI respectively, as shown in Figure 3-1.

3-37 Remote Sensing is used to maintain good regulation at the load and reduce the degradation of regulation which would occur due to the voltage drop in the leads between the power supply and the load. Remote sensing is accomplished by utilizing the strapping pattern shown in Figure 3-8. The power supply should be turned off before changing strapping patterns. The leads from the sensing terminals to the load will carry much less current than the load leads and it is not required that these leads be as heavy as the load leads. However, they should be twisted or shielded to minimize noise pickup. Remote sensing leads longer than 15 feet may have high frequency resonances which can cause the power supply to oscillate. If long leads are anticipated consult your local Hewlett-Packard Sales Engineer for techniques to eliminate oscillation.

3-38 Note that it is desirable to minimize the voltage drop in the load leads and it is recommended that the drop not exceed 1 volt per lead if the power supply is to meet its dc specifications. If a larger drop must be tolerated, please consult an HP Sales Engineer.

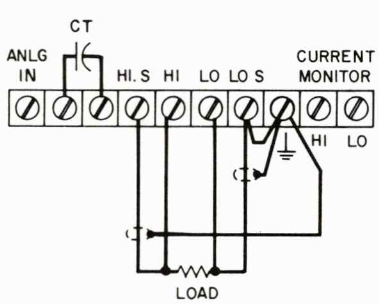


Figure 3-8. Remote Sensing, Strapping Pattern

3-39 Grounding. Proper grounding will greatly reduce output ripple and noise. It is recommended that the LO output terminal be connected to the GND terminal. The HI output terminal should not be connected to GND during normal operation.

3-40 If the output terminals must be floated at some dc potential, a capacitor (between 0.05 and 0.1μF) should be connected between the LO and GND terminals. If the above capacitor is not connected, a common-mode noise signal will be induced in the output leads. Since this noise signal will have an amplitude of approximately 100mV, it is recommended that the above capacitor be utilized.

3-41 CURRENT MONITOR

3-42 The CURRENT MONITOR terminals (Figure 3-8) can be used to monitor the output current of the DVS without affecting the output voltage. To monitor the output current, a DVM is connected across the CURRENT MONITOR HI and LO terminals. The output voltage reading is proportional to the current output in the ratio of 1 volt/1 ampere output current. With a positive output programmed through a resistive load, the LO terminal is positive with respect to the HI terminal. The accuracy of the CURRENT MONITOR reading is ±3% ±2mA. For example, a reading of 250mV indicates that the DVS output current is 250 ±9.5mA.

3-43 ANALOG INPUT

3-44 The ANLG IN terminal (Figure 3-8) can be used to program the output of the DVS with an analog input. The analog input signal can be a dc level or a variable signal (a sinewave, for instance). The analog input signal is connected between the ANLG IN and LO S terminals.

3-45 The analog input is summed with the digital voltage magnitude data (after it is converted to its equivalent analog current) at the input to the DVS power amplifier. The result of the summation is used to drive the power amplifier which produces the specified output voltage. Since the power amplifier inverts its input, the analog input voltage must be of opposite polarity with respect to the polarity of the desired output voltage. The power amplifier amplifies the input signal by 1 in the X1 range and by 10 in the X10 range.

CAUTION

To protect the DVS from damage, the combination of digital voltage magnitude data and analog input should not cause the DVS to exceed its rated limits (±100Vdc). Further, regardless of the digital voltage input, the analog input in the X1 range should not be greater than ±20V nor greater than ±10.0V in the X10 range.

3-46 The DVS output voltage can be determined by the following formula: V_{OUT} = -Range x Analog Input + Digital Program Voltage. For example if a +5.000Vdc output is desired with no digital voltage program input, a -5.000Vdc input can be applied to the ANLG IN terminal with the DVS set to the X1 range. The equation is: $V_{OUT} = -1 \times (-5.000) + 0 = +5.000$Vdc. This same output, of course, could also be obtained by applying a -0.500Vdc input with the DVS in the X10 range. Negative DVS output is obtained in a similar manner; that is, by applying a positive analog input at the ANLG IN terminal. The bandwidth of the analog input (measured at the -3dB point) is approximately 25kHz. In other words, the gain of the power amplifier falls off if the analog input frequency exceeds 25kHz with the amplifier approaching unity gain at 100kHz.

SECTION IV
PRINCIPLES OF OPERATION

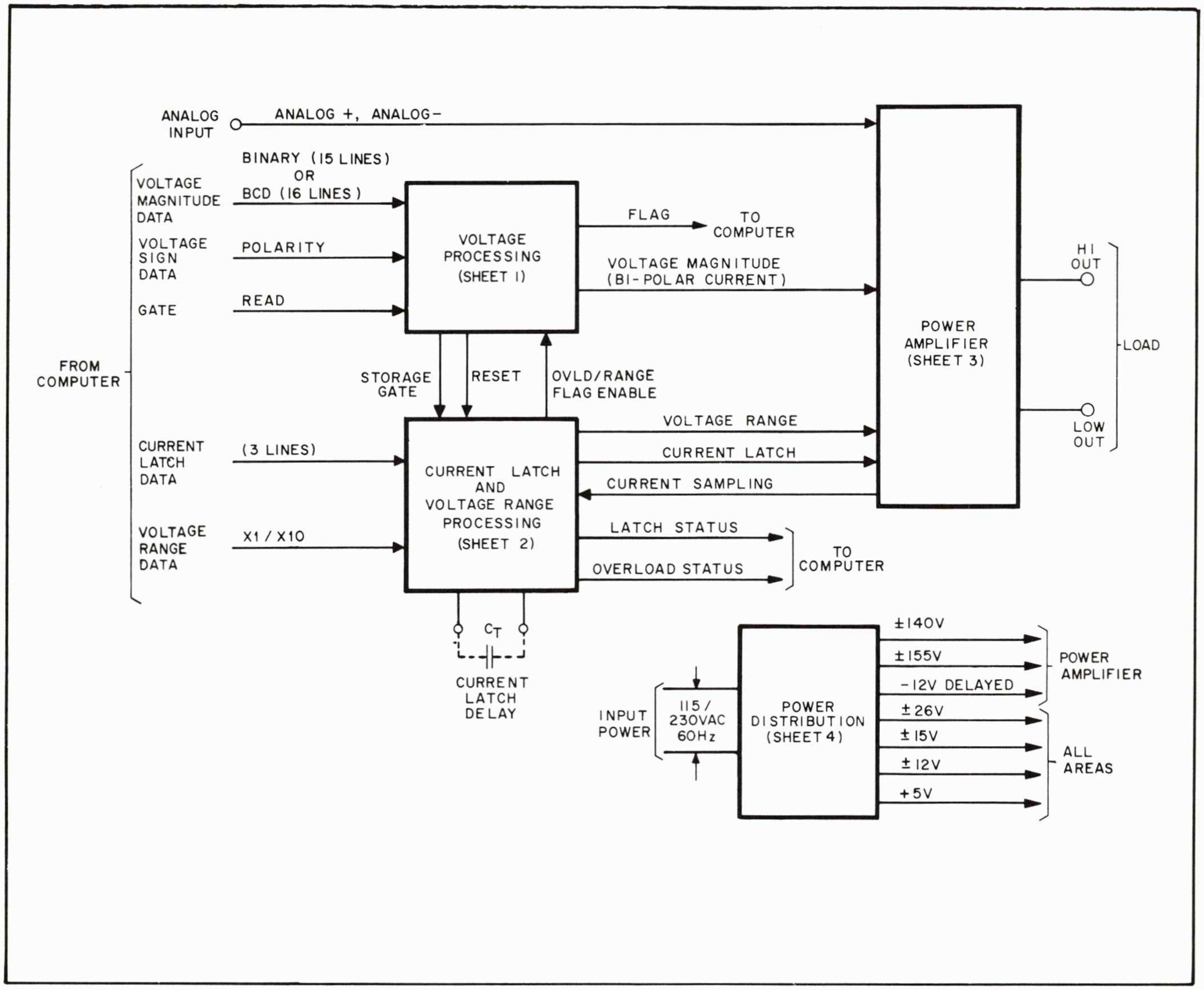


Figure 4-1. Basic Block Diagram

4-1 INTRODUCTION

4-2 This section contains the principles of operation for the Digital Voltage Source (DVS). The section is divided into three main paragraphs; a basic block diagram discussion, a detailed block diagram discussion, and a detailed circuit analysis. The depth of coverage increases with each level of discussion until, in the detailed circuit analysis, the function of each major component is described using the schematic diagrams of Figure 7-2.

4-3 BASIC BLOCK DIAGRAM DISCUSSION

4-4 Figure 4-1 is a basic block diagram of the DVS showing its four major circuits, together with the principle input/output signals of each circuit. Each major circuit has an associated sheet number for correlation of this diagram with the schematic sheets at the rear of the manual.

4-5 The Digital Voltage Source is a digital-to-analog "link" capable of providing an accurately

settable source of dc or low frequency ac power. It provides -9.999 to +9.999 volts (in 1mV steps) or -99.99 to +99.99 volts (in 10mV steps) at 0 to 0.5A, from dc to 25kHz. Current limit protection is provided by a current "latch" circuit which can be programmed to activate at one of six values; ranging from 20mA to 500mA. Back-up protection is provided by a gross current limit circuit which prevents the output current from exceeding 110% (maximum) of the rated output current.

4-6 VOLTAGE PROCESSING

4-7 The voltage processing circuits interface, isolate, store, and convert to analog form the digital input data representing the magnitude and sign of the required output voltage. The input circuits adapt the DVS to the requirements of the driver circuits to be used and provide dc isolation between the computer ground and the DVS output. Integrated circuits store the received data and a digital-to-analog converter translates the stored data to a bi-polar analog current. This bi-polar analog current signal controls the output of the power amplifier.

4-8 The input gate signal initiates timing and storage functions for both the voltage processing and current latch and voltage range processing circuits. The storage function allows the voltage processing circuits to continuously provide a voltage magnitude output without the need for repeated voltage magnitude and sign inputs from the computer. Each time the input gate is received, a storage gate reset signal and a flag are generated. The storage gate signal initiates the storage function within the current latch and voltage range processing circuits. The reset output signal resets the current latch circuit if (1) the circuit is in the latch condition; and (2) if the condition that originally caused the latch has been corrected. The reset signal is ignored if these two conditions have not been satisfied.

4-9 The flag output provides timing information to the computer concerning the status of the voltage processing and current latch and voltage range processing circuits. It is generated in response to the gate input or the overload/range enable inputs from the current latch and voltage range circuits.

4-10 CURRENT LATCH AND VOLTAGE RANGE PROCESSING

4-11 Current latch and voltage range processing circuits interface, isolate, store, and process input digital information to provide the current latch and voltage range output signals to the power amplifier. Input circuits, similar to those used in voltage processing, adapt the DVS to the computer circuits and provide dc isolation. Integrated circuits store the information when the storage gate is received from voltage processing. The stored current latch and voltage range data is then processed by separate circuits as will be described in subsequent paragraphs.

4-12 Current Latch Processing. The three lines of current latch data are decoded and are used to establish a reference current limit which is compared with a sample of the output current. If the current sample equals, or exceeds, the reference current limit, a current overload status signal is immediately sent to the computer informing it that an overload condition exists. If the overload condition still exists after a variable delay period, the current latch and current latch status output signals are simultaneously generated. The current latch delay period is approximately 5 to 10μsec with the C_T terminals open and with added capacitance can be extended to 2msec. The time delay should be extended for applications involving capacitive loads to prevent surge currents from initiating premature current latch action. When the C_T terminals are shorted, the current latch circuitry is disabled inhibiting the generation of the current latch and latch status output signals. If generated, the current latch output signal turns off the power amplifier so that the output current is reduced to a safe value (less than 10mA). The latch status signal informs the computer of the current latch status of the DVS.

4-13 Whenever a current overload or latch condition occurs, an overload flag enable signal is sent to the voltage processing circuits which, in turn, issues a flag output to the computer.

4-14 Voltage Range Processing. The voltage range data input is stored, and then sent as a voltage range select signal to control the power amplifier range relays. With the relays energized, the voltage program input signal is multiplied by 1 (X1 range). With the relays deenergized, the voltage magnitude is multiplied by 10 (X10 range). Similar to current overload condition, a range flag enable, and then a flag signal is issued whenever a voltage range change occurs.

4-15 POWER AMPLIFIER

4-16 The power amplifier amplifies the bi-polar voltage magnitude input current to provide a bipolar output voltage across the load connected between the HI and LO output terminals. An external analog input signal can also be applied to the power amplifier. A signal applied to the analog input terminal is summed with the voltage magnitude signal from voltage processing. For this condition, the power amplifier amplifies the sum

of these signals. Shunt feedback is employed to prevent changes in the output voltage without a change in the input signal. Additional feedback networks are used within the amplifier stages for stability purposes.

4-17 As mentioned previously, the amplifier circuits multiply the current input signal by X1 or X10, depending on the status of the voltage range input from the voltage range processing circuit.

4-18 The power amplifier includes a self-contained, gross current limit circuit which is fixed to activate at 110% (maximum) of the rated output current. When activated, the gross current limit circuit limits the conduction of the power amplifier preventing the output current from exceeding the maximum current limit value.

4-19 Additional protection for the load is provided by a circuit which shorts the output of the amplifier whenever input power is interrupted or the input cable from the computer is disconnected.

4-20 POWER DISTRIBUTION

4-21 Power distribution circuits accept 115 volts or 230 volts, single phase, 60Hz input power and provide unregulated dc bias voltage outputs to the three major circuits. Additional regulated bias voltages are generated by reference supplies and voltage regulators in voltage processing and the power amplifier. Overload protection is provided by a fuse in the input circuit. The delayed -12 volt output to the power amplifier provides protection of the output load by keeping the amplifier output shorted until the internal bias supplies within the DVS have stabilized.

4-22 DETAILED BLOCK DIAGRAM DISCUSSION

4-23 Figure **7-1** is a detailed block diagram of the Digital Voltage Source showing each stage, or group of stages, within each of the three major circuits. The major circuits are bracketed by heavy-weight lines and sheet numbers are provided to correlate this drawing with the overall schematics of Figure 7-2. For the sake of simplicity the bias supplies and regulators are not included on Figure 7-1; but are discussed in the detailed circuit analysis.

4-24 The detailed block diagram discussion describes, in block diagram terms, the operation of each major circuit. Details concerning the components inside the many circuit blocks are given in the detailed circuit analysis which also includes information on the internal adjustments and controls. Waveforms and timing diagrams are included throughout to supplement the text. For ease of understanding, the waveforms are idealized. The waveforms are keyed to various points on Figure 7-1 by means of encircled test point numbers.

4-25 VOLTAGE PROCESSING

4-26 The voltage processing circuits consist of an input board, logic board, and a digital-to-analog converter board. The circuits will be explained functionally based on signal flow from board-to-board. A timing diagram for the voltage processing circuits is included on Figure 7-1.

4-27 Voltage Magnitude Input Data. Incoming voltage magnitude data is in 8-4-2-1 binary-coded decimal form with sixteen input data lines controlling the four decimal digits of the output voltage.

4-28 Input Isolators. Voltage magnitude and voltage sign data input isolators provide the logic interface and dc isolation required between the user's computer and the DVS. Incoming voltage magnitude data is applied first to a resistive voltage divider which establishes voltage levels that can be readily utilized by the DVS. DC isolation is provided by a photo-isolator. The input isolator circuit inverts the polarity of the input data, and, in the case of PNP driver circuit, converts it to signal levels appropriate to the NPN logic circuits of the DVS.

4-29 Gate Input and Timing. The gate input (TP1) initiates storage and other timing functions within the DVS. As described in Section III (Figure 3-4) the leading edge of the gate must be received at least 10μsec before the voltage magnitude (data) and sign bits are terminated.

4-30 The input gate signal is first level-set by a resistive voltage divider and then inverted, if necessary, to ensure that the 3-microsecond delay circuit receives a positive-going input transition. The 3-microsecond delay circuit produces a 3-microsecond negative pulse (TP4) whose trailing edge activates the 50-microsecond delay circuit. The two complementary outputs of the 50-microsecond delay are 50-microsecond pulses delayed from the input gate by 3-microseconds. The 3-microsecond delay ensures that the resulting storage gate occurs after the start of the incoming data pulses. The negative 50-microsecond gate pulse (TP6) serves as the input to the gate pulse isolator while the positive output is the input to the flag isolator.

4-31 The flag output to the computer (TP16) is produced by an OR gate whose inputs are the 50-microsecond pulse (TP40), a pair of pulses occurring at the beginning and end of a current overload, and a 2-millisecond pulse which occurs during a change

in voltage range. Waveforms for the flag output signals may be found in Figures 3-4, 3-5, and 3-7. The isolator for the flag signal output permits the output amplifier/inverter to be biased and configured to interface with the computer's receiver circuit. The trailing edge of the 50-microsecond flag produced by a gate input informs the computer that voltage processing is complete and the unit should be producing the requested output. The gate pulse isolator provides dc isolation. The isolator output (TP7) triggers the gate pulse generator and also resets the current latching flip-flop. The gate pulse generator produces a 2-microsecond positive pulse (TP8) with its leading edge delayed by 3-microseconds from that of the input gate.

4-32 With the storage disable switch in the STORE position, the gate pulse generator output pulse is the input to an OR gate whose output (TP9) is the storage gate for voltage magnitude and voltage sign bits. Putting the storage disable switch in the DISABLE position substitutes a fixed positive voltage for this pulse. This permits the bits to pass directly through the storage flip-flops. The output of the OR gate either gates or disables the current latch and voltage range storage flip-flops in the same manner.

4-33 As the unit is turned on, the initial gate pulse generator produces a storage gate input to the OR gate that assures that the storage flip-flops are in the desired initial state.

4-34 Storage. Having storage capability permits the DVS to provide a continuous output after initial data is no longer present. Sixteen latching flip-flops are provided for the voltage magnitude bits and one for sign storage. A storage gate (TP9) strobes the flip-flops, allowing the magnitude and sign inputs to either set or reset them. If the data source is either NPN negative logic or PNP negative logic, the non-inverting outputs of the voltage storage flip-flops are connected. For positive logic inputs, the inverting outputs are connected. The proper outputs are selected by locating the voltage magnitude storage flip-flop packages at appropriate locations on the board. Since the data has already been inverted once by the input isolators, the outputs of the flip-flops (TP97) are high for the bits of the incoming data from the computer that are ones. The logic sense of the sign bit is adapted to the DVS logic by jumpers at the output of the sign amplifier and inverter. This circuit receives the output of the sign storage flip-flop and sends S and $\bar{S}$ control signals to the nines complement logic and a sign signal (TP107) to the polarity offset switch. Together, these latter two circuits determines the polarity of the output voltage. Storage can be disabled by an internal switch on the logic board, in which case the outputs of the storage flip-flops follow the data inputs continuously. The voltage magnitude data from storage is applied to the nines complement logic.

4-35 Nines Complement Logic. The nines complement logic carries most of the burden of polarity changing in order to allow a single D/A converter to furnish a bipolar output. Any positive input number, as determined by the sign bit, is converted into its nines complement. In other words, the number (N) representing the desired output is subtracted from 9.999 in BCD form (9.999 - N). For example, if the digit A inputs 0100 (4) and digits B, C, and D are 0000 (decimal input of 4.000), then the digit A output will be 0101 (5) and the digit B, C, and D outputs will be 1001 (9), resulting in a converted BCD output of 5.999 from the nines complement logic. A negative reference current, equivalent to a numerical value of 9.999, is later subtracted from the nines complemented output within the D/A converter.

4-36 For negative input numbers, the nines complement function is not performed and incoming numbers are gated directly through the nines complement logic without alteration of their values (input = 4.000; output = 4.000). Gates within the nines complement circuits are controlled by sign inputs S and $\bar{S}$ which determine whether or not nines complementing occurs.

4-37 Digital-To-Analog Converter. The digital-to-analog converter converts the digital data to either a positive polarity analog current (for negative voltage magnitude inputs) or a negative polarity analog current (for positive voltage magnitude inputs). The latter is accomplished by a negative reference current applied to the converter by the polarity offset switch whenever the input is positive. The magnitude of the D/A converter output current varies between plus and minus 0.9999mA according to the value of the incoming voltage and sign data.

4-38 The D/A converter contains a series of switches (transistors) which are activated by the input data bits from storage. These switches then act on a resistive ladder network which produces an output current (in milliamperes) which is proportional to the numerical value of the input data. The combined output of the ladder network and the polarity offset switch make up the voltage magnitude signal. This signal is applied to the power amplifier where it is summed with the current produced by the external analog input, if any. The algebraic sum of these currents is inverted by the power amplifier and appears at the output terminals as the programmed output voltage.

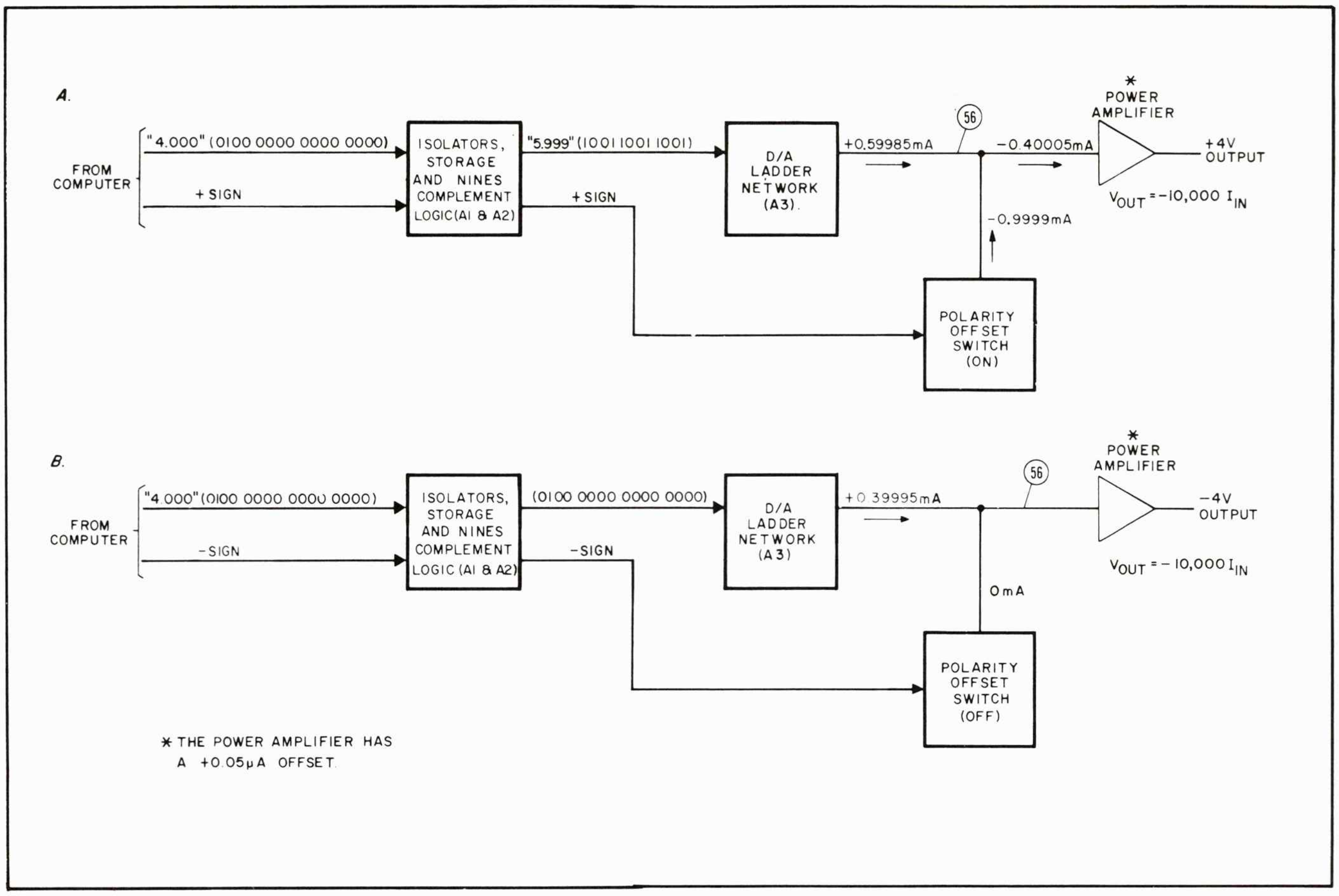


Figure 4-2. Voltage Processing Circuits, Simplified Schematic

4-39 Polarity Offset Switch and -10V Reference. For digital input data bearing a negative sign, the polarity offset switch is turned off by the sign input from storage and has no effect on the operation of the D/A converter. Under these conditions, the D/A converter supplies a positive output current which is proportional to the applied BCD data. For positive digital input data, the sign input turns on the polarity offset switch and a negative reference current of 0. 9999 milliamps is applied to the D/A converter from the -10-volt reference supply. The negative reference current is then summed (within the D/A converter) with the positive current from the ladder network which is numerically equivalent to the nines complemented value of the original input data. The resulting output is a negative analog current which has been restored to the original numerical value of the positive input data (prior to nines complementing) by the addition of the -0. 9999 milliamp reference current. Figure 4-2 illustrates the operation of the voltage processing circuits using examples of +4V and -4V binary coded decimal inputs.

4-40 POWER AMPLIFIER

4-41 The precision power amplifier consists basically of three major stages; a feedback differential amplifier, coupling amplifier, and power amplifier. Negative feedback is employed, from output to input, creating a near zero impedance summing junction at the input of the feedback differential amplifier. The amplifier provides an output of -1 volt for every 100μA of input current ($E_{OUT} = -10,000 \times I_{IN}$) in the X1 range or -10 volts for every 100μA of input current ($E_{OUT} = -100,000 \times I_{IN}$) in the X10 range. Hence, in the X1 range, the D/A converter supplies its maximum input current of approximately ±999. 9 microamperes to obtain a ±9. 999 volt output. For the X10 range, however, the D/A converter need provide only ±1000μA to attain the maximum rated output of ±100 volts. If a number larger than 50 is programmed in the X10 range, the additional D/A input current has little effect on the output because the output of the amplifier is internally limited to approximately (110%) 55 volts.

4-42 Feedback Differential Amplifier. This circuit amplifies and inverts the D/A output and/or analog input signal before applying it to the coupling amplifier. It provides most of the voltage gain of the overall amplifier. Negative feedback is employed with an equalizing network which shapes the high frequency responses for stability purposes.

4-43 Voltage Range. A range input from the voltage range processing circuits controls the operation of the range relays which, in turn, determine the impedance of both the equalizing and main feedback networks. In the X1 range, the relays are energized reducing the impedance of the feedback networks and thus increasing the amount of negative feedback through both networks. In the X1 range the overall amplification is multiplied by a factor of 1. In the X10 range, the relays are deenergized, multiplying the amplification by 10.

4-44 Coupling Amplifier. This inverting stage couples the input stage of the overall amplifier to the power amplifier stages which are at a much higher power level. The voltage and current gain of the coupling amplifier is minimal.

4-45 Power Amplifier. The power amplifier stage furnishes most of the current gain of the overall amplifier. The output stage is a class AB_1 push-pull complementary connected amplifier which produces the positive or negative output voltage. The output, at the high sense terminal, is fed back to the input of the overall amplifier resulting in a constant output voltage which is independent of load variations.

4-46 Current Latch Input. The current latch signal is received from the latch processing circuits if the preselected current latch value is exceeded. An isolating oscillator first isolates the power amplifier from the current latch circuit. The isolator output then activates the current latch switch which turns off the power amplifier.

4-47 Under current latch conditions, the non-conducting power amplifier presents an impedance of approximately 20KΩ in series with the high output terminal. The output current is limited to between 0 and approximately 10mA, depending on the programmed output voltage and the type of load.

4-48 Gross Current Limit. The positive and negative gross current limit comparators provide additional current limit protection. They are fixed to operate at the maximum current limit of approximately ±0.55A providing protection for the DVS and the load during the variable current latch delay period or in the event of failures in the current latch circuit.

4-49 The comparators each monitor the voltage drop across the current sampling resistor. Since the IR drop across the sampling resistance varies in proportion to the output current, both comparators effectively monitor the output current of the DVS. The use of two comparators allows sampling of output current flowing in either direction; with the negative gross current limit comparator monitoring negative output currents, and the positive comparator monitoring positive output currents. For normal source currents (below the ±0.55A threshold) the comparators are biased below cutoff and do not influence amplifier operation. However, if the gross current limit threshold is exceeded, the appropriate comparator conducts sending a gross current limit signal to the coupling amplifier. This signal turns down the coupling amplifier, and hence the power amplifier, preventing the output current from exceeding the maximum current limit. For sink currents, the trip point is reduced.

4-50 Disconnect Interlock. A disconnect interlock relay provides load protection by shorting the output of the DVS whenever the computer cable is disconnected or source power is interrupted. Under these conditions, the relay is deenergized (as shown on Figure 7-1) and contacts of the relay short the output terminals. The output is also shorted at turn-on (for approximately 0.2 seconds) and turn-off of the unit which protects the load from possible transients during these times. For normal operating conditions, the relay is energized removing the short between the output terminals and connecting the interlock signal 2 to the current latch and voltage processing circuits.

4-51 Metering Circuits. The metering circuits provide continuous indications of output voltage and current on the front panel meters. The meters operate in conjunction with front panel range switches and appropriate resistive voltage dividers to permit voltage display in one of two ranges and current indications in one of three ranges.

4-52 CURRENT LATCH AND VOLTAGE RANGE PROCESSING

4-53 These circuits are located on the control board A6. They consist of input isolating circuits, storage, decoding, current sampling and current overload circuits. The circuits will be described functionally based on signal flow from input to output.

4-54 Input Data. The current latch data input from the computer consists of a three bit binary code which is shown in Section III of this manual. This code establishes the point at which the DVS will current latch. The voltage range data input is a single binary bit which determines the voltage range, X1 or X10.

4-55 Input Isolators. Four input isolator circuits, identical to the voltage magnitude input isolators described above, are utilized. They provide the logic interface and dc isolation for the current latch and voltage range data signals from the computer.

4-56 Storage and Storage Disable. In store mode, the three bits of current latch data (TP74) are stored in flip-flops along with the one bit of voltage range data (TP76). These storage flip-flops are enabled by the storage gate and are identical to the ones used in the voltage processing storage circuit. If the storage disable switch in the voltage processing circuits is in the DISABLE position, these flip-flops as well as those in voltage processing are disabled and pass data directly through without storing it. The three current latch data output lines from storage (TP75) are applied to the current latch decoder and the voltage range storage output (TP73) to the range pulse generator.

4-57 Current Latch Decoder. The current latch decoder generates a reference voltage for each of the six current latch bit combinations. As just mentioned, the current latch bits are received from storage. The incoming bits are first converted to an analog reference current which is then used to develop the negative reference voltage. This voltage is fed directly to the negative current comparator and to the negative reference inverter which provides an equal amplitude, opposite polarity reference voltage to the positive current comparator.

4-58 Current Comparators. The positive and negative current comparators compare a sample of the output current (voltage drop across the current sampling resistance) with the negative or positive reference. If the IR drop across the sampling resistance equals, or exceeds, the reference voltage, an overload signal (TP17-Figure 4-3) is generated. The polarity of the output current determines which of the comparators is activated. The overload signal is fed both to the current overload circuits (isolator and overload flag generator) and the current latch circuit (variable delay). Once the unit switches to the current latch mode, the output current is reduced to under 10mA and the current overload signal at TP17 reverts to its normal state.

4-59 Current Overload Circuits. The current overload circuits comprise an isolator, output amplifier, and overload flag generator. The isolator, a photo isolator of the type used throughout the DVS, provides dc isolation between the computer and the DVS. The output amplifier interfaces the DVS overload circuits with the computer receiver circuits by providing an overload status signal (TP25) of the proper magnitude and polarity.

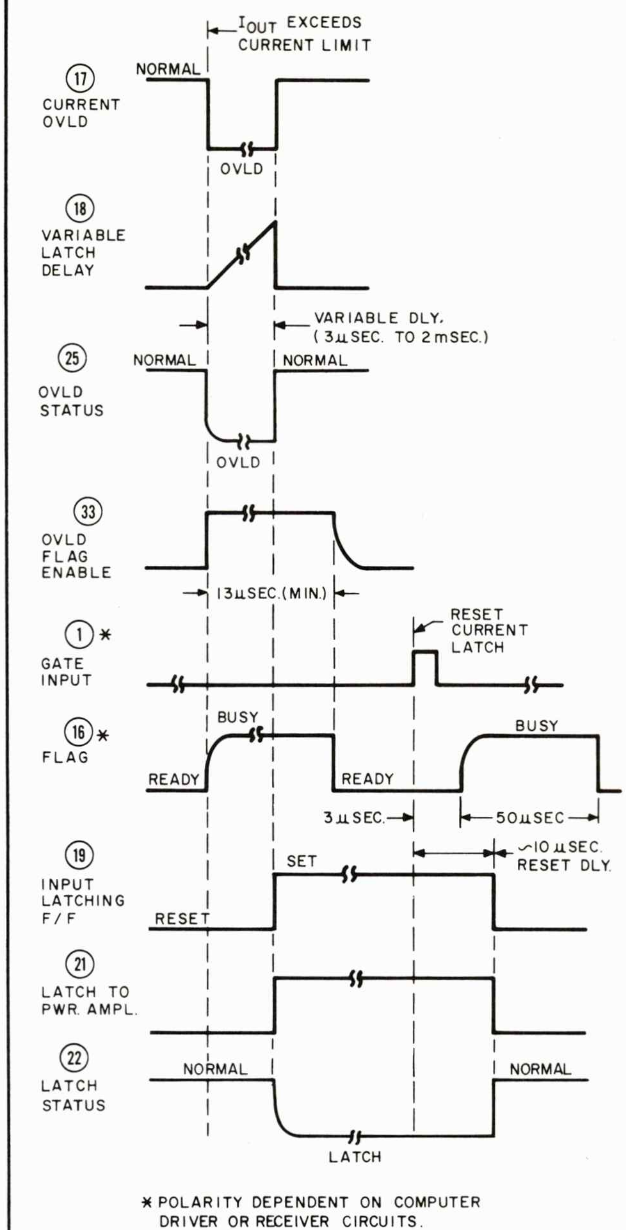


Figure 4-3. Current Overload and Latch Circuits, Timing Diagram

4-60 The overload flag generator provides a 10µsec wide flag enable output signal (TP33) at both the leading and trailing edges of the current overload signal at TP17. The first trip signal indicates the start of an overload while the second denotes that current latch has occurred. If the variable delay period is less than 10µsec, note that the trip signals at TP33 will overlap and

appear as one signal. Since the minimum latch delay is approximately 3μsec, the minimum trip signal width is 13μsec. The overload flag trip signals are OR'ed with the voltage range flag signal and then applied through a photo-isolator and an output amplifier to the voltage processing circuits. This signal (overload/range flag enable) is applied to an OR circuit in the voltage processing circuits which in turn generates the flag signal which is applied to the computer through another photo-isolator and an output amplifier/inverter circuit.

4-61 Current Latch Circuits. These circuits are composed of a variable delay, level detector, latching flip-flop, reset amplifier, isolator, and output amplifier. If a current overload condition persists for a certain preset delay period, these circuits generate a current latch signal. The current latch signal ultimately biases the power amplifier to cutoff, or near cutoff, limiting the output current to less than 10mA. A current latch indicator signal is also generated if a current latch condition occurs.

4-62 The variable delay circuit delays the fall time of the current overload input (TP17). The degree by which the leading edge of this signal is retarded, determines the current latch delay period. The variable delay circuit operates in conjunction with the C_T terminals on the rear of the unit. As mentioned previously, the condition of these C_T terminals determines the current latch delay. With the C_T terminals open, a natural delay period of from 3μsec to 10μsec results. If the user connects a capacitor across the C_T terminals, the current latch delay period can be extended from 5μsec to 2msec at the rate of approximately 1μF per msec. The user can also disable the current latch circuits by shorting the C_T terminals. This disables the variable delay circuit preventing the generation of the current latch signals to the power amplifier and computer. The user could employ this method during testing or troubleshooting when the unit is "off line", or in any case where programmable latching is not desired.

4-63 When the input at TP18 (Figure 4-3) becomes sufficiently positive the level detector (a Schmitt trigger) is activated. The positive going output (TP19) sets the latching flip-flop which, in turn, provides a current latch signal (TP21) to the power amplifier and a latch status signal (TP22) to the computer via an isolator and output amplifier. Similar to the other output circuits in the DVS, this amplifier issues a latch status output signal which is of the polarity and amplitude necessary to interface with the computer receiver circuits.

4-64 The latching flip-flop remains set until approximately 10μsec after the next gate input (TP1) is received from the computer. The leading edge of the 50μsec delayed signal (TP7) is amplified and used to reset the flip-flop. Notice that if the current overload still exists after the latch is reset, the entire current overload and current latch process is repeated and the unit will again revert to the current latch state.

4-65 Voltage Range. The voltage range circuits consist of a range pulse generator and a 2msec delay circuit. The voltage range, similar to the current latch, is established by the voltage range data bit from the computer. The range pulse generator provides two outputs; one for the range relays in the power amplifier and the other for the generation of a voltage range flag signal to the computer. If the input voltage range bit calls for the X1 range, the range pulse generator connects a 2 common to the power amplifier range relays to energize them. In the X10 range, the range relay lead is open and the relays are deenergized. The range pulse generator also provides a negative output pulse for each positive or negative transition of the voltage range input. The positive going output triggers a 2msec delay circuit which provides the voltage range flag signal. This signal is OR'ed with the overload flag signal and applied to the voltage processing circuits through a photo-isolator and an output amplifier. The overload/range flag enable output signal drives the flag OR circuit in the voltage processing circuits. An example of a voltage range flag is shown on Figure 3-5. The 2msec delay period allows time for operation of the range relays and for processing of the voltage range input bit.

4-66 DETAILED CIRCUIT ANALYSIS

4-67 VOLTAGE PROCESSING (See Figure 7-2, Sheet 1)

4-68 Input Isolator Circuits. The input isolator circuits (A1-A16) for the sixteen voltage data bits and for the sign bit (A17) are all identical. They employ light-emitting-diode/phototransistor isolators to eliminate dc paths between the computer and the DVS output. A biased attenuator network (R1, R2, and R3) makes it possible, by selecting appropriate values, to adapt to either of the standard BCD interface options, or, through resistor choice and/or resistor bias polarity, to adapt to other driver circuits as required, whether NPN or PNP. The logic convention of the source may either be positive true or negative true (See Figure 4-4). The voltage levels and circuit details for the inputs (and outputs) of instruments having either of the standard options are given in the appropriate Option Appendix in the back of this manual. Interface information for other instruments is given on the Instrument Modification Sheet included with the instrument.

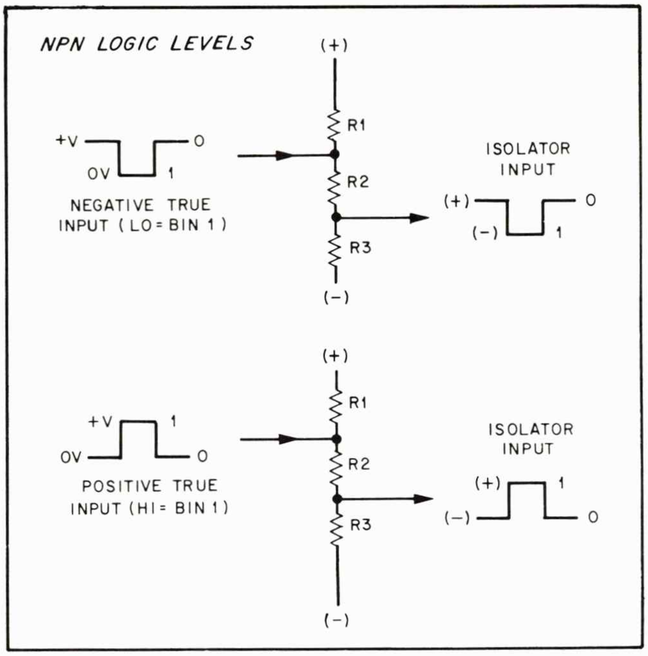


Figure 4-4. Input Voltage Divider Networks

4-69 When the input (TP10) is at its more positive level, Q1 is turned on and energizes the LED in photo-isolator assembly Z1. The photons emitted by the diode cause the phototransistor to conduct, turning on Q2 to apply a low to the data input (TP13) of the storage flip-flop for that data bit. CR1 and R5 form a low impedance load for the photo-transistor to minimize its switching time. A more negative level from the computer produces a high input to the flip-flop. Note that a signal level inversion occurs between the isolator input and output.

4-70 Storage. When a high level is present at the clock inputs of the storage circuits, the level present at the data inputs appears at the Q outputs and the complement of that data at the $\overline{Q}$ outputs. The output of the sign flip-flop is not inverted. Whatever data is present when the clock input becomes low is stored in the flip-flops and continues to appear at the outputs until the next high clock input occurs. In STORAGE DISABLE mode, the clock input remains high. The logic board has two sets of four sockets for the voltage magnitude storage IC packages. One set is designated A1Z7 through A4Z7 and connects the inverting ($\overline{Q}$) outputs. The other, A1Z1 through A4Z1, connects the non-inverting (Q) outputs. The proper choice of sockets for these IC's depends on the interface requirements of the DVS and whether an inversion of the voltage magnitude bits is needed. The sixteen voltage magnitude outputs from storage to the D/A converter must be high for those bits that are true. The voltage sign output from storage must be low for a positive output voltage and high for a negative one. Since one inversion occurs at the input isolators, positive true voltage magnitude inputs from the computer require the use of the inverting Z7 sockets and positive true inputs require the non-inverting Z1 sockets to be used. The proper polarity of the sign bit is obtained by positioning jumpers W1 and W2 in the B position for positive = HI inputs and the A position if the input is positive = LO.

4-71 Nines Complement Logic. The nines complement logic, operating in conjunction with the voltage sign input, provides a nines complement conversion of each BCD input digit when the programmed output is positive, or provides a straight-through transfer of the BCD digits when the programmed output is negative. The operation of the digit A circuit with a programmed input of +4. 000 volts is described in the following paragraphs.

4-72 With a +4. 000 volts input programmed, the input to inverter AR4 is at a high logic level while the inputs to AR1, AR3, and AR5 are low. When any positive output is programmed, the S output from the sign amplifier and inverter is a high and the $\overline{S}$ output is a low. Since the output of AR4 is low, the output of gate G1 is high. Low inputs at pin 2 of G2 and pin 9 of G3 produce two high inputs to G4 so that pin 2 of G6 is low and its output is high. Since both inputs to G5 are low, its output is also high. These two high inputs to G7 produce a low G7 output. This low forms the nines complement bit 8 output. Two high inputs to G8 produce a low G8 output and a high G10 output. The S signal, which is high, is combined with the output of G10 to produce a low output from G12. This low establishes a high output from G13. This high forms the nines complement bit 4 output. Since the bit 2 digit of a number is always the same as that of its nines complement, the low input to AR3 is also connected to serve as the low output for bit 2. Since the output of AR5 and the S control signal are both high, the output of G15 is low and the output of G16 (which is the bit 1 output) is high. The high levels at the bit 1 and bit 4 outputs constitute a decimal output of 5, which is the nines complement of the decimal input, which was 4.

4-73 When a negative output is programmed, the logic levels of the S and $\overline{S}$ control signals are reversed so that S is low and $\overline{S}$ is high. Gates G6, G12, and G15 are disabled by the S input to produce high inputs to G7, G13, and G16. These high inputs enable these gates while the high $\overline{S}$ signal enable gates G5, G11, and G14. Thus the bit 8, bit 4, and bit 1 inputs to gates G5, G11, and G14 are each inverted twice by two enabled gates to appear at the outputs of G7, G13, and G16 at the same logic level as the outputs from

storage. The bit 2 input is wired directly to the output as was explained above. Section V of this manual contains tables which define all pertinent logic levels within the nines complement logic for all valid input codes, both positive and negative. See Table 5-4 and 5-5 for this information.

4-74 Gate Input and Timing. In instruments equipped with one of the standard options, the gate input from the computer (TP1) is a negative-going transition. A biased attenuator network (R1, R2, and R3) identical to those of the voltage and sign bit inputs adapts the gate input to the interface requirements of the driver circuit. Inverter Q2 provides the positive-going transition needed at the input (TP3) of one-shot multivibrator Z3, which has a Schmitt trigger input sensitive to positive levels. For special modifications, an additional inverting stage that is normally jumpered out may be added ahead of Q2 to accommodate a positive-going input gate. The 3-microsecond duration of the negative pulse at the output of Z3 (TP4) is determined by the values of R7 and C5. The trailing edge of the negative 3-microsecond pulse triggers another one-shot multivibrator identical to the first except that its timing components, R8 and C6, cause it to produce an output pulse 50-microseconds long. Multivibrator Z4 produces a negative 50-microsecond pulse at its $\overline{Q}$ output (TP6) and a positive 50-microsecond pulses at its Q output (TP40). Both of these pulses start 3 microseconds after the start of the incoming gate. The negative output (TP6) drives the light-emitting diode of the gate pulse isolator circuit. This isolator circuit, similar to those used for the voltage magnitude inputs lines, produces a negative output pulse (TP7). This pulse is inverted by part of A2Z2 in order to obtain the positive-going transition (TP43) needed to drive another one-shot multivibrator (A2Z6). A2Z6 is identical to A1Z3 and A1Z4 except that its timing components are chosen for a 2-microsecond output pulse (TP8).

4-75 If the storage disable switch is in the STORAGE position, this 2-microsecond positive pulse is applied to one of the inputs of the OR gate composed of Q1, Q2, and Q3. The output of the OR gate (TP9) is a positive 2-microsecond storage gate to the clock inputs of the voltage magnitude and sign flip-flops. This output is also inverted by another section of A2Z2 and sent to the current latch and voltage range processing circuits to control the storage flip-flops there. The other input of the OR gate is connected to an r-c differentiating network that produces a 20-millisecond pulse when the instrument is energized. This pulse assures that the A2 and A6 storage flip-flops are in the desired initial state.

4-76 If the storage disable switch is in the STORAGE DISABLE position, an input gate does not produce a storage gate. The pulse input to the OR gate is disconnected by the switch and Q1 is saturated by the current through R2. The continuously high output from Q2 keeps all of the storage flip-flops enabled so that data inputs are reflected at the flip-flop outputs continuously. Placing the switch in STORAGE DISABLE also lights the STORAGE DISABLE lamp.

4-77 The other output of multivibrator A1Z4, the 50-microsecond positive pulse (TP40) mentioned above, is one of two input signals to an OR gate consisting of A1CR1 and A6CR20. The other input will be discussed under current latch and voltage range processing. The output of this OR gate (TP31) feeds the flag isolator, which is similar to the input isolators described above. In this instance, the isolator is not used to isolate the computer from the DVS output, since the input and output are both referenced to common $\boxed{3}$. Here it is used to make it possible to shift the dc level of the output stage so that it can interface with either an NPN or a PNP receiver circuit.

4-78 Following Q5 of the flag isolator are two optional amplifier/inverter stages, Q6 and Q7. The standard options either include an NPN Q6 stage as an inverter, if that option requires a ready = LO and busy = HI output, or else leave Q6 out if the reverse logic sense is required. Other instrument modifications may require an NPN or a PNP output of either logic sense. To provide an PNP output, jumpers W1, W2, and W3 are connected so that the entire output side of the isolator is connected between -12 volts and common $\boxed{3}$ and PNP transistors are used for Q6 and Q7. Circuit details depend on interface requirements. Refer to the appropriate Option Appendix or the Instrument Modification Sheet for this unit.

4-79 Digital-To-Analog Converter. The digital-to-analog circuits consist of bit switches and ladder networks, a polarity offset switch and two reference voltage circuits. The D/A converter provides discrete output currents as determined by the voltage data input bits from the nines complement logic. This circuit is composed of four similar sets of bit switches and resistive ladder networks. The switching circuits consist of transistors A3A1Q1-Q3 through A3A16Q1-Q3 while the analog ladder networks consist of resistors A3R50 through A3R96. Since all four networks are similar, only the network for the most significant digit is described in the following paragraphs.

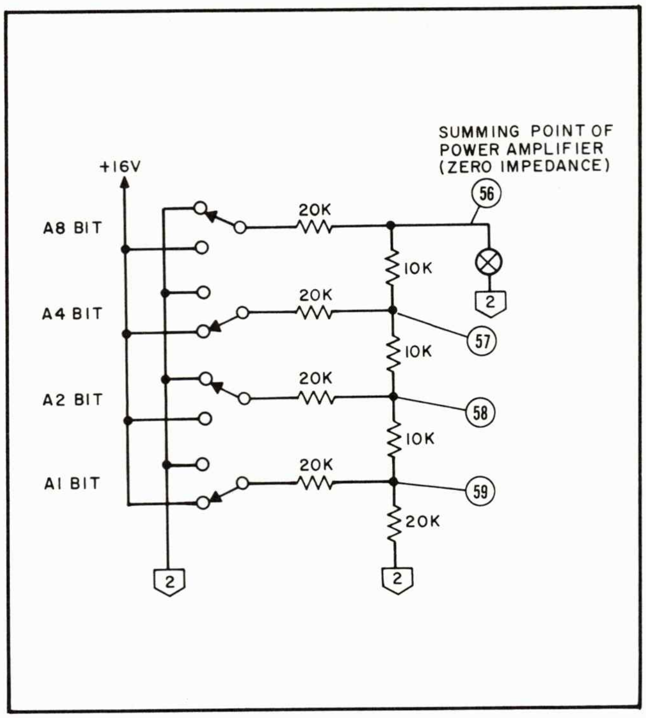


Figure 4-5. Ladder Network, Simplified Schematic

4-80 The bit switch network consists of a driver, Q1, and two low-saturation switching transistors, Q2 and Q3. With a voltage program input of +4.000V, the digit A circuits receive a nines complemented input of 5 (0101). The low (binary 0) at the base of A3A16Q1 is inverted, and through steering diode CR2 causes switch Q3 to conduct, placing a ground on the bit 8 input to the analog ladder network at TP56. The high (binary 1) input at the base of A3A15Q1 is inverted, and through steering diode CR1, causes Q2 to conduct, placing a +16 volt level on the bit 4 input to the ladder network (TP57). The remaining digit A switches produce a ground and a +16 volt level at their respective ladder network inputs. In the simplified schematic of Figure 4-5, the switching transistors are represented by mechanical switches connecting each of the four rungs of the analog ladder network to either +16 volts or ground (2). Again, the switch positions represent the BCD input of 0101, the four most significant bits of the nines complemented input of 4.000 volts.

4-81 Figure 4-6A shows the voltages at the input of each rung. To determine the current flowing into the summing point ((X)) from the digit A ladder, a Thevenin Equivalent can be constructed for each rung. If the circuit is broken above TP59, the open circuit voltage at TP59 is 8 volts and the impedance looking into TP59 is 20K in parallel with 20K, or 10K. Thus the Thevenin Equivalent is 8 volts in series with 10K, as shown in Figure 4-6B. Breaking the circuit above TP58 and replacing this portion by its Thevenin Equivalent, we have the circuit shown in Figure 4-6C. Now, breaking the circuit above TP57 and solving for the voltage at this point we are left with the remainder of the circuit as shown in Figure 4-6D. This figure shows that the current flowing into the summing point TP19 is 10V/20K = 0.5 milliamps.

4-82 The current flowing into the summing point from the other three ladder networks may be solved in the same manner and the results will be : digit B = 0.09mA, digit C = 0.009mA, and digit D = 0.0009mA. Summing all four currents yields a total current of 0.5999 milliamps flowing into the summing point from the ladder network when a nines complemented input of 0101 1001 1001 1001 is present at the inputs to the D/A board. As described previously, this +0.5999mA ladder network output is summed with -0.9999mA from the polarity offset switch yielding a net input to the power amplifier of -0.4000mA. This input is inverted and amplified by 10X to produce a +4.000V DVS output voltage.

4-83 Potentiometers A3R52 through A3R59 are adjusted to compensate for the conducting resistances of Q2-Q3 and resistance tolerances within the network. With these controls properly adjusted, the total series resistance in each rung is 20KΩ as shown in Figures 4-5 and 4-6. Notice that the output current of each of the four ladder networks is weighted in powers of 10. Thus, resistor A3R92 divides the digit B output current by 10, resistors A3R93 and A3R94 divide the digit C output current by 100, and resistors A3R95 and A3R96 divide the digit D output current by 1000.

4-84 Polarity Offset Switch Circuit. This circuit consists of amplifier A3Q13 and switch A3Q14. A constant reference of slightly greater than 10 volts is supplied to the emitter of switch Q14. With a negative sign input A3Q13 receives a high level input signal and switch A3Q14 does not conduct. With a positive input sign, however, Q13 receives a low input causing Q14 to saturate. A path for the offset current of -0.9999mA is now completed to the summing point. Potentiometer A3R100 provides a means of adjusting the offset current.

4-85 +16 Volt Reference Circuit. This circuit provides a regulated output voltage of +16Vdc. To maintain the output voltage constant, a series regulating feedback loop is employed. A reference comparator circuit. AR-Z1, compares a portion of the output voltage (across divider R34, R36, and AR-R3) with an internal zener diode reference voltage. If a difference exists, the comparator

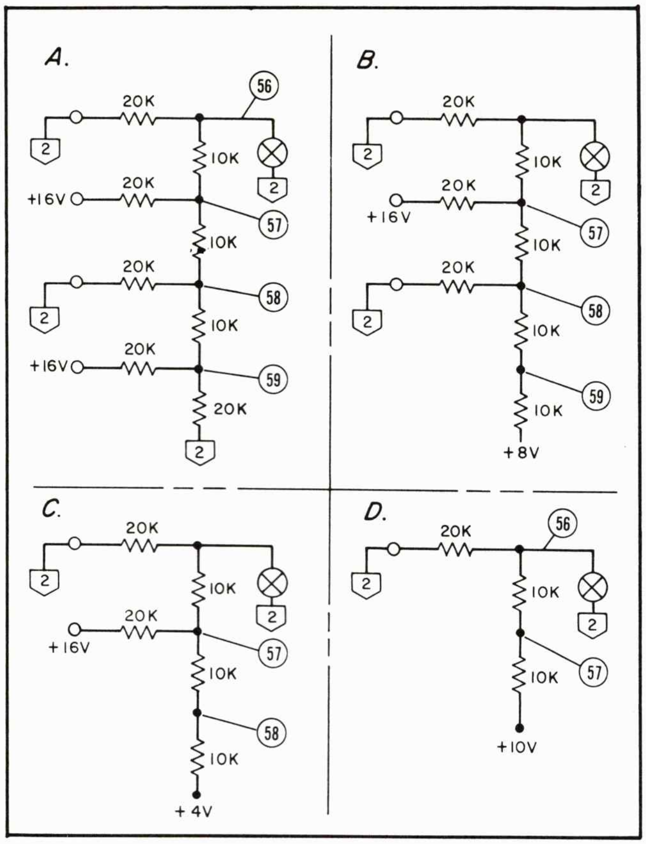


Figure 4-6. Ladder Network, Thevenin Equivalents

sends an error signal to series regulator Q31 via driver Q32. This error signal is of the phase and amplitude necessary to counteract the original difference. Transistor Q30 provides a constant biasing current of Q32 and AR-Z1. Potentiometer R36 can be adjusted to alter the voltage divider resistance and thus, the +16 volt output. Output capacitor C30 stabilizes the feedback loop.

4-86 -10 Volt Reference Circuit. This regulator circuit is similar to the +16 volt reference supply except that the -10 volt reference supply utilizes the regulated +16 volts as one of its dc inputs in a kind of "Auto-Tracking" configuration. With this technique, any change in the +16 volt output causes an equal percentage change in the -10 volt output thereby minimizing inaccuracies in the D/A converter due to drift or other disturbances. The -10 volt reference supply contains a series regulating feedback loop composed of: comparison amplifier Q11, error amplifiers Q12 and Q15, and series regulator Q10. Incipient changes in the -10 volt output are detected by Q11B, amplified by Q12 and Q15 and applied to the series regulator. Feedback loop stability is maintained by output capacitor C13 and feedback network C12, R21.

4-87 +21.5 Volt Regulator. A regulated +21.5 volts is obtained from series regulator A3Q40 and zener diode VR40 which keeps the base voltage of Q40 at a constant level.

4-88 CURRENT LATCH AND VOLTAGE RANGE PROCESSING (See Figure 7-2, Sheet 2)

4-89 Input Isolator Circuits. The four input isolators (A6A1 through A6A4) for the latch bits (range, 50mA, and 30mA) and the voltage range bit are identical to those used in voltage processing (refer to paragraph 4-68). The current latch range (X1 or X10) input bit (L24) is at a positive level for the X1 range and a more negative level for the X10 range. The 30mA and 50mA bits (L22 and L23) of current latch data must be in LO = true, negative logic form. For example, when the 30mA input (L22) is LO (more negative level), the 30mA bit is present, and when the 30mA input is HI (more positive level), the 30mA bit is absent. The voltage range input bit is at a more negative level for the X1 range and a positive level for the X10 range. The input isolators invert these input levels.

4-90 Storage. The current latch and voltage range storage flip-flops (A6Z2) are identical to those used on board A2 in voltage processing. When a high storage gate level is present at the clock inputs to the storage flip-flops, the levels present at the data inputs appear at the Q outputs and the complement of that data at the $\overline{Q}$ outputs. Whatever data is present when the storage gate (clock) input becomes low is stored in the flip-flops and continues to appear until the next high clock input occurs. In the storage disable mode, the clock input remains high, and the flip-flops pass the data bits directly through to the current latch decoder and range pulse generator without storing them.

4-91 Storage Gate. The storage gate circuit develops the clock signals for the storage flip-flops. The storage gate signal is received from the logic board in the voltage processing circuits and is applied to the base of Q4 through speed up network (C1 and R62). Q4 and R63 comprise a level setting circuit to provide the proper interface with the logic board. Note that the emitter of Q4 is returned to 4 (-26V) while the emitters of Q5 and Q6 are connected to 2 . The storage gate signal is inverted by Q5 and again by Q6 to provide the proper clock level to the storage flip-flops.

4-92 Current Latch Decoder. This circuit converts the three coded current latch bits to an analog output current. Eight possible analog output currents can be obtained; one for each of the eight current latch bit combinations. The output current of the current latch decoder appears at a current summing junction (collectors of A6Q11, Q12, and

Q13) and is determined by the conduction of these transistors. The resultant current at the junction flows through A6R30 and A6R37 to develop negative and positive reference voltages, respectively, for the comparators.

4-93 Current latch range is determined by the range bit which turns on A6Q1 in the X1 range and turns off A6Q1 in the X10 range. With Q1 on, (X1 range) a path is completed for the voltage divider network (R8-R13) in its collector circuit. Bias voltages which are less positive now permit transistors Q8, Q9 and Q10 to conduct, effectively shorting out resistors R16, R17, and R18, respectively, in the base circuits of Q11, Q12, and Q13. This action insures that the conduction of Q11 is decreased by a factor of 10. If transistors Q12 and/or Q13 are conducting, their conduction is likewise 10x less than that of the X10 current latch range.

4-94 Transistor Q11 is biased in its active region and always conducts one of two fixed amounts of reference current to the summing junction. As just described, the two fixed currents vary by a factor of 10 and depend on the status of the current latch range bit.

4-95 Transistors Q12 and Q13 may, or may not, be conducting depending on the status of the 50mA and 30mA current latch input bits. If transistor Q2 is conducting, Q14 is cut off and Q12 (50mA stage) does not conduct. Under these conditions, no reference current is supplied to the summing junction by Q12. Conversely, when Q2 is cut off, Q12 is allowed to conduct one of two fixed amounts of current as determined by the current latch range bit. Transistor Q13 (30mA stage) is controlled in a similar manner by the 30mA bit and the range bit.

4-96 To better illustrate the action of this circuit, assume that the programmed current latch is 20mA (the three current latch data inputs are all HI). In this case, transistors Q12 and Q13 are not conducting because of high level inputs to Q2 and Q3. Transistors Q1 and Q8 are conducting thus limiting the conduction of Q11 to its X1 range value. If a 200mA current latch is programmed (same as above except current latch range data input is LO), transistors Q12 and Q13 are cut off, as before, but range transistor Q1 is not conducting. This cuts off Q8 and the conduction of Q11 is increased to its X10 value.

4-97 Negative and Positive Current Comparators. The current comparators compare the voltage drop across current sampling resistor A5R5 (proportional to the output current) with the voltage drop across A6R30 or A6R37 (proportional to the current latch value). If the output current equals or exceeds the current latch reference value, one of the Z4 comparators (positive or negative) generates a negative going current overload signal to turn on the appropriate OR gate diode (CR1 or CR2). The polarity of the output current determines which of the comparators is activated. The positive current comparator (Z4, R32, R34, R43) is activated for positive output currents to monitor the difference between the output and latch reference current. The current sampling signal (J6-N) is one input to the positive current comparator and the positive reference signal is the other input. The positive reference signal is developed by the negative reference inverter (Z3 and Q23). For excessive positive output currents, the positive current comparator generates a negative-going output signal causing CR2 to conduct. The negative current comparator (Z4, R31, R33, R39) is activated for negative output currents to monitor the difference between the output and latch reference currents. The current sampling signal is one input to the negative current comparator and the negative reference signal is the other input. For excessive negative output currents, the negative current comparator generates a negative-going signal causing CR1 to conduct. With CR1 or CR2 conducting, an overload signal is passed to the current latch and current overload circuits.

4-98 Current Latch Circuits. If a current overload signal is generated, these circuits generate a current latch signal which turns off the power amplifier. The latch output signal is not generated until after variable delay period has elapsed. The delay ranges from approximately 3μsec to 2msec. Variable delay stage, Q16, receives the overload signal and, if the C_T terminals are open, passes the inverted signal on to Q17 with a minimal delay (less than 1μsec). Under these conditions, the latch delay period is dependent solely on the natural circuit delays of the level detector, latching flip-flop, current latch switch, and the power amplifier (see Sheet 3). The time required to initiate turn-off at the power amplifier with the C_T terminals open is approximately 3 to 10μsec.

4-99 For greater latch delays, a capacitor can be connected across the C_T terminals. When Q16 is cut off by the negative-going overload signal, the positive-going slope on its collector is now determined by the time taken by capacitor C_T to charge through R42. Hence, increasing the value of C_T increases the latch delay period.

4-100 Shorting the C_T terminals places the collector of Q16 at (2) potential preventing Q17 from conducting. This prevents the unit from operating in the current latch mode. Note that if the unit is already in the current latch mode shorting the C_T terminals will not transfer it out of current latch.

4-101 Level Detector. Transistors Q17 and Q18 form a Schmitt trigger circuit which switches state when the positive-going input signal reaches the threshold level. Transistor Q17 conducts when the threshold is reached biasing Q18 below cutoff. The positive-going rise on the collector of Q18 is then coupled through limiting diode CR9 to set the latching flip-flop. When current latch commences. the Schmitt trigger input goes negative cutting off Q17 and returning the circuit to its original stage. The latching flip-flop remains in the set state, however, because diode CR9 blocks the negative going excursion of the collector of Q18.

4-102 Latching Flip-Flop. Transistors Q19 and Q20 are connected in a bi-stable multivibrator configuration. When the DVS is not in a current latch condition, the flip-flop is in the reset state with Q19 off and Q20 on. Reset is initiated by a short duration negative pulse applied to the base of Q20 by reset amplifier Q24. The reset pulse is generated 3μsec after the application of a gate input from the computer. The leading edge of the 50μsec wide input from input board A1 cuts off Q22. The output of Q22 is differentiated by A6C4 and A6R52 and the positive going spike that occurs at the leading edge of the input is inverted by Q24 and then used to turn on Q20.

4-103 A current latch condition is initiated by a positive going transition applied to the base of Q20 from the collector of Q18. This sets the flip-flop by turning Q20 off causing Q19 to turn on. The flip-flop remains in the set state until a gate pulse is received from the computer and a reset pulse is generated by Q24.

4-104 The latching flip-flop is also set when the shorting relay (A4K1) is deenergized (Figure 7-2, Sheet 3). This ensures that the power amplifier is turned off when the output terminals are shorted by contacts of relay A4K1.

4-105 Buffer and Current Latch Status Circuits. The buffer amplifier (A6Q21) inverts the negative going latch signal from Q20 and applies it to the power amplifier (Figure 7-2, Sheet 3) and to the latch status isolator/output amplifier (A6A5). The isolator (A6A5Z1, Q1, Q2) is similar to the input isolators previously described. The latch status isolator provides a LO output to indicate latched status and a HI output for normal condition. The output amplifier stages A6A5Q3 and A6A5Q4 that follow A6A5Q2 provide sufficient current drive and proper signal inversion to interface with the computer. Circuit details depend on interface requirements. Refer to the appropriate Option Appendix or the Instrument Modification Sheet for this unit.

4-106 Current Overload Circuits. The current overload circuits consist of an overload flag generator, isolator, output inverter, and a overload status isolator/output amplifier circuit. If the current latch value is exceeded, the negative going overload signal at TP17 is applied to the overload flag generator and to the overload status isolator and output amplifier circuit.

4-107 Overload Flag Generator. The overload flag generator consists of two emitter coupled amplifier stages A6Q29 and A6Q30. The collector stage of each amplifier contains a differentiating network (C13, R95 and C14, R94) and a limiting diode (CR14 and CR15). The limiting diodes conduct only the positive excursion of the differentiated waveform from the respective collector. These diodes also serve as part of the flag enable OR gate along with A6CR16 which receives the voltage range flag. The first output pulse from the overload flag generator is obtained from the collector of Q29. It is initiated by the negative going overload signal (begin current overload) which turns off Q29 turns Q30 on. This causes a negative voltage change at the collector of Q30 and a positive change at the collector of Q29. The positive portion of the differentiated Q29 output is conducted by CR14 while the nagative portion of this waveform and the output of Q30 are blocked. The component values of the differentiating network determine the 10μsec width of the conducted pulse. The trailing edge (begin current latch) of the overload signal turns Q29 on and Q30 off resulting in a second 10μsec pulse at TP33 through CR15. This pulse is obtained from the collector of Q30 and is a replica of the first overload pulse.

4-108 Figure 4-7 illustrates the output pulses obtained from the flag generator (TP33) for a current latch delay of 20μsec. Because the output pulses from the flag generator have a fixed width of 10μsec, the output waveforms at TP33 will merge if the current latch delay is less than approximately 10μsec . For example, if the current latch is 10μsec, the waveform at TP33 consists of a single pulse having a width of approximately 20μsec.

4-109 Overload/Range Flag Isolator and Inverter. The positive (high) output from the OR gate (TP33) is applied to the overload/range flag isolator and inverter circuit. The photo-isolator circuit (A6Q31, Z5, Q32) is identical to those previously described. The low output at the collector of Q32 is applied to the base of inverter Q33 to produce a high at the collector of Q33 which is conducted through A6CR20. Diode A6CR20 along with diode A1CR1 comprise on OR gate input to the flag isolator and output amplifier/inverter circuit (Figure 7-2, sheet 1).

4-110 Overload Status Isolator and Output Amplifier. The overload status isolator and output

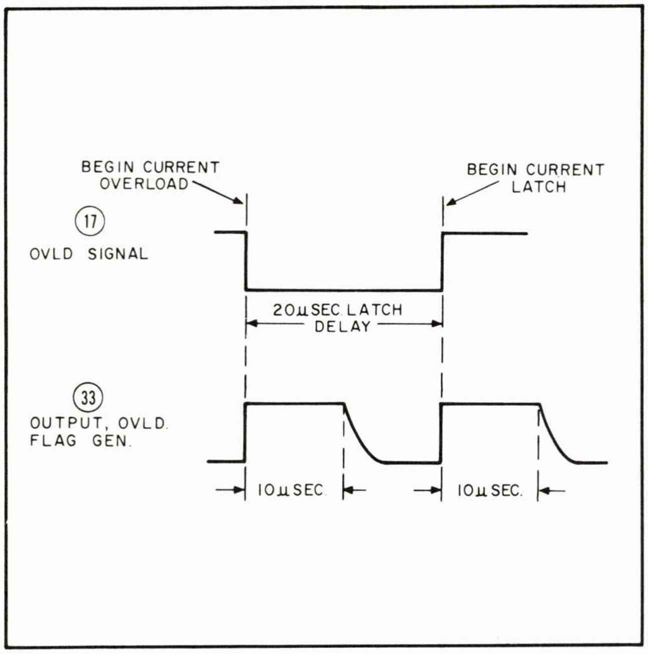


Figure 4-7. Overload Flag Generator Output With 20μsec Latch Delay

amplifier (A6A6) is similar to the latch status isolator and output amplifier (A6A5), described in paragraph 4-105. For a latch condition, the input to A6A5 is positive causing A6A5Q2 to conduct. For an overload condition, the input to A6A6 is negative causing A6A6Q2 to cutoff. Inverter A6A6Q3 provides a LO output to indicate an overload status. Stage A6A6Q4 is omitted for the standard options.

4-111 Voltage Range Circuits. The voltage range circuits energize or deenergize the voltage range relays in the power amplifier and also provide a 2msec wide flag output to the computer whenever the voltage range is changed. For the X10 range, the range input bit is a positive level causing the range storage flip-flop to provide a low input to the base of Q25 (range pulse generator). This holds Q25 off, opening the collector lead which is connected to the range relay coils (Sheet 3) via A5J6, pin D. Hence, in the X10 range the relays are deenergized.

4-112 For the X1 range, the range input bit is a negative level causing the range storage flip-flop to provide a positive input causing Q25 to conduct coupling 2 common to the range relay coils to energize them. Differentiating networks and limiting diodes (C8, R74, CR12 and C9, R75, CR13) in the base and collector circuits of Q25 couple positive going transitions to the base of Q26 in the 2msec delay circuit whenever a change in range occurs.

4-113 The 2msec delay circuit is composed of transistors Q26 and Q28, connected in a type of one-shot multivibrator configuration, and transistor Q27 which provides current gain between the one-shot stages. In the stable state, transistors Q28 and Q27 are conducting and Q26 is held off due to the voltage drop across common emitter resistor, R81. Coupling capacitor C11 charges up to nearly +10V through conducting transistor Q27. When a range change occurs, a positive going transition is received from the range pulse generator. The multivibrator now is driven into its unstable state with Q26 on and Q27, Q28 off. It remains in the unstable state for approximately 2msec until C11 discharges (through R82 and R83) sufficiently to allow the conduction of Q28. The range flag enable output is coupled to the flag output circuit (Sheet 1) via OR gate diode A6CR16.

4-114 POWER AMPLIFIER (See Figure 7-2, Sheet 3)

4-115 Feedback Differential Amplifier. This circuit consists of three differential amplifier stages followed by a single-ended stage. The first two stages (A7Q1 and A7Q2) each consist of two silicon transistors housed in a single package. The transistors have matched characteristics to minimize differential voltages due to mismatching or thermal drift.

4-116 Diodes A7CR3 and A7CR4 protect the input stage, Q1A, from being overdriven by excessive inputs from the D/A Converter and/or the external analog input. Voltage divider A7R1, R2, and R3, connected to the base of the input stage, provides a zero reference bias with no applied input signal. The voltage magnitude input from the D/A converter is summed with the external analog input and the resultant analog current applied to the base of the differential amplifier input stage. The collector circuits of each of the first three differential amplifiers contain RC networks (C1, R6-C2, R16-C4, R25) which help prevent amplifier oscillations. Potentiometer A7R9, in the base circuit of Q1B, can be adjusted to compensate for slight differences between the two base voltages of the input stage, thus zeroing the output voltage.

4-117 The output of the feedback differential amplifier is taken from the collector of A7Q5 and applied to the coupling amplifier, A7Q6. Negative feedback is employed, from the collector of Q5 to the base of Q1A, for equalization purposes. Zener diode VR7 improves the response time of the feedback amplifier by its clamping action at the collector of Q5.

4-118 Range relay A7K2 switches in the proper value equalizing network for each range; C22 and R88 in the X10 range, or these components in par-

allel with C23 and R89 in the X1 range. Relay A1K1 changes the range by changing the overall feedback resistance by a factor of 10. The overall feedback line, from the high sensing terminal to the base of Q1A, contains resistors R85, R86, and R87 in the X10 range, In the X1 range, the relay is energized thus shorting out R85 and R86.

4-119 The normal output voltage swing at the collector of Q5 is between -1 volt and -6 volts. These two extremes represent output voltages + 100V and -100V, respectively. Q5 provides an output of approximately -3V when the output voltage is zero.

4-120 Coupling Amplifier. Inverter Q6 serves as a "level changing" transistor, coupling the relatively small negative output level of Q5 to the 155 volt level used in the power amplifier. The gain of the coupling amplifier is small, only slightly greater than one. If the gross current limit is exceeded, the coupling amplifier receives a turn-down signal from Q23 (if positive output voltage gross current limit is exceeded) or Q20 (if negative output voltage gross current limit is exceeded). The operation of the positive and negative gross current limit circuits is described in subsequent paragraphs.

4-121 Power Amplifier. The power amplifier consists of three push-pull stages which are of complementary symmetry design. The input stage Q10 and Q12, is driven by a single-ended stage, Q7. For positive output currents the positive section of the amplifier (transistors Q10, Q11, Q1, Q2, Q5, Q30, Q31, Q14, and Q15) is conducting while the negative section (transistors Q12, Q13, Q3, Q4, Q6, Q32, Q33, Q16, and Q17) is cutoff. The reverse is true for negative output currents. At zero output current, both halves of the power amplifier are conducting slightly with diodes CR17, CR18, and CR22, providing the voltage drop necessary to forward bias Q10 and Q12 simultaneously. This eliminates "dead spots" when the unit is programmed away from zero.

4-122 Transistor Q7 is a voltage amplifier, having a gain of approximately 40, while the three emitter-coupled push-pull stages provide most of the total current gain of the power amplifier. Hence, the voltage at the bases of the push-pull input stage (Q10 and Q12) is essentially equal to the output voltage of the unit. Q7, together with VR10, R36, CR16-CR18, CR21, CR22, R38, R91 and VR11 form a voltage divider network in the base circuit of the input stage. The conduction of Q7 controls the current flowing through the voltage divider and, thus, the bias at the bases of the input transistors. Zener diodes VR3, VR4, VR8, and VR9, connected to the bases of Q10 and Q12, prevent the output voltage from exceeding approximately ±110 volts. Diode CR19 protects Q10 and Q12 from the effects of possible reverse voltages.

4-123 Under current latch conditions, transistors Q10 and Q12 are biased below cutoff due to the conduction of Q8 and Q9, part of the current latch switch circuit. The conduction of these transistors effectively shorts the bases of Q10 and Q12 to the high output terminal, reducing the bias current to zero. The current latch switch and isolator circuits are described in succeeding paragraphs.

4-124 The second push-pull stage (Q11 and Q13) on the A7 amplifier board drives the power output transistors (Q1 through Q6) which are mounted on the rear heat sink. These transistors are connected in series between the +140V and -140V supplies. The conduction of Q2 or Q3 is controlled directly by the output of Q11 or Q13; depending on which half of the amplifier is active at the time. The conduction of the other series transistors (Q1 and Q5 or Q4 and Q6) is controlled by the positive or negative bias transistors (Q14, Q15, Q30, and Q31; or Q16, Q17, Q32, and Q33).

4-125 The function of the bias networks is to divide the voltage drop (and thus the power dissipation) among the three series connected power transistors in the active branch. This is accomplished by sensing the programmed output voltage level and using it to develop two additional voltages; one representing the output voltage plus 2/3 of the difference between 140 volts and the output voltage, and the other representing approximately 1/3 of the same value. For the positive bias network, R116 and R115 develop the 2/3 voltage function while R118 and R117 develop the 1/3 voltage function. (R126 through R129 perform the same function for the negative bias network.) The 2/3 voltage level at the junction of R116 and R115 is power amplified by compound emitter followers Q30 and Q31 and appears at approximately the same 2/3 voltage level at the emitter of power transistor Q5. The 1/3 voltage level is similarly amplified by Q14 and Q15 and appears at the emitter of Q1. From this it can be seen that 1/3 of the voltage drop between 140 volts and the programmed voltage level appears across each of the three series connected power transistors. The negative bias network operates in a similar manner.

4-126 The remaining components of the bias networks improve general circuit operation. Diodes CR37 through CR40 protect the base-emitter junctions of the input bias transistors from becoming excessively reverse biased; resistors R104, R105, R106, R108, R109, R111, R112, R113, R119, R121, R122, and R130 offset undesirable leakage currents; and capacitors C13, C14, C15, and C17 permit the circuit to respond to rapid changes in programmed

output voltage.

4-127 Gross Current Limit Comparators. The positive and negative current limit comparators protect the output transistors of the power amplifier by limiting the maximum output current to a safe level for both source and sink conditions. The output current for normal source conditions is limited to a fixed maximum of 0.55A; for sink conditions the maximum current is a linear variable ranging from 0.25A at 100V (at HI output terminal) to 0.55A at 0V. Because the two current limiters are so similar only one, the positive limiter, is described in detail.

4-128 When the output current is within specified limits, transistor Q21 is biased on, Q22 and Q23 are cutoff, and diode CR23 is reverse biased. Under these conditions the limiter has no effect on the output current. Zener diode VR12 together with resistors R46 and R47 form a bias network that holds the base voltage of Q22 slightly more positive than the base voltage of Q21, and thus establishes a positive current limit switching level. If the output current starts to exceed the source current limit of 0.55A, the voltage drop across sampling resistor A5R5 increases and produces a voltage level at the base of Q21 equal to the base voltage of Q22. With zero differential voltage between Q21 and Q22, Q22 comes out of cutoff switching on Q23 and forward biasing CR23. The negative voltage coupled through CR23 clamps the power amplifier output current to a maximum of 0.55A. Back-to-back diodes CR28 and CR29 protect the base-emitter junction of Q22 from voltage transients caused by surge currents through A5R5.

4-129 During sinking conditions the normally positive output voltage becomes negative. This negative voltage is fed back through diodes CR30 and CR31, and influences the positive current limit switching level at the base of Q22. As the output voltage becomes increasingly negative, the positive current limit switching level decreases so that Q22 will switch on and initiate current limiting at an output current level less than 0.55A.

4-130 Current Latch Isolator and Switch. These two circuits operate in conjunction with the current latch circuits on the A6 Control Board. The current latch isolator circuit consists of switching transistor A7Q25 and tuned-collector oscillator A7Q24. A positive going transition at the current latch input at the base of A7Q25 causes it to conduct. The resultant output at its collector, is fed to the emitter of A7Q24 via swamping resistor A7R70. This allows A7Q24 to conduct through the 10MHz tank circuit (T1 primary winding and capacitor C20) in its collector circuit. Voltage divider resistors R68 and R69 establish the base bias. Regeneration for sustained oscillation is coupled from the collector winding of T1 to the base winding. Each end of the T1 output winding contains a rectifier-filter network in order to drive the push-pull current latch switch, A7Q8 and A7Q9. Rectifiers CR7 and CR8 conduct on the positive half cycles; rectifier diodes CR11 and CR12 conduct on the negative half cycles. Under latch conditions, both, Q8 and Q9 conduct to zero bias the power amplifier push-pull input stage (A7Q10 and A7Q12).

4-131 Disconnect Interlock. Relay A4K1 and driver transistor A4Q1 protect the load by shorting the output terminals of the DVS under certain conditions. The output terminals are shorted when K1 is deenergized. This occurs if the $\boxed{3}$ common input from the computer is removed or the -12V DELAYED is not present. When the unit is first turned on, K1 is also deenergized because the -12V bias input is delayed for approximately 0.2 seconds after turn-on. Notice that the current latch circuits are activated at this time and, thus, must be reset with a gate input before the unit can be restored to normal operation. The output is also shorted at turn off of the unit because the -12V bias input collapses rapidly causing K1 to deenergize.

4-132 POWER DISTRIBUTION (See Figure 7-2, Sheet 4)

4-133 The ±12V, ±26V, ±140V, and ±155V bias and supply voltages are obtained from power supply board A4. The + 5V is obtained from chassis mounted + 5 volt regulator Z1. Note that the + 5V supply is referenced to $\boxed{4}$ which is at -26V with respect to $\boxed{2}$, the common potential for the ±26V supply. The ±12V supply is referenced to $\boxed{3}$ which is connected to the computer ground. The ±12V, ±26V ±140V, and ±155V supplies are simple networks containing rectifier diodes, filter capacitors, and bleeder resistors.

4-134 Amplifier board A7 contains two regulator circuits for deriving ±15V outputs from the ±26V inputs. Each circuit is composed of a series regulator (Q26 or Q28) and an input comparator stage (Q27 or Q29). The input stage compares a portion of the output voltage with a fixed reference voltage (across VR5 or VR6). If a difference exists, it generates an error voltage which is of the correct amplitude to counteract this difference.

4-135 Boards A1, A2, A3, and A6 contain filter capacitors for various supply voltages. In addition, board A1 contains zener diodes and resistors to develop + 5V referenced to $\boxed{3}$ and board A6 contains a series regulator A6Q34, resistors, and a zener diode to provide + 4.99V referenced to $\boxed{2}$. Series regulator A6Q34 also provides a + 14.5V output referenced to $\boxed{2}$.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance test (Paragraph 5-6) should be made. This check is suitable for incoming inspection. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-37). After troubleshooting and repair, perform any necessary adjustments and calibrations (Paragraph 5-69). Before returning the power supply to normal operation, repeat the performance test to ensure that the fault has been properly corrected and that no other faults exist. Before performing any maintenance checks, turn on the power supply and allow a 30-minute warm-up.

5-3 TEST EQUIPMENT REQUIRED

5-4 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

NOTE

In certain maintenance procedures (including troubleshooting), DVS plug-in boards are required to be mounted on the Extender Board (supplied with the DVS). The extender board includes an epoxy plate that is positioned with screws on either side of the extender board printed circuit board to interface with the particular plug-in board being extended. The following extender board screw positions (for the epoxy board) are to be used for extending the associated plug-in board:

	Extender Board Position	Associated Plug-In Board
Side A	A	D/A (A3)
	B	Logic (A2)
	C	Input (A1)
	D	Control (A6) and Power Amplifier (A7)
Side B	E	Not Used
	F	Not Used
	G	Not Used
	H	Not Used

Note further that when a board is extended, the front panel cover should be completely removed to avoid any possibility of inadvertently touching the plug-in board to the front panel cover.

5-5 To conveniently program the DVS, the Hewlett-Packard Pocket Programmer Model 14533B is recommended. A three-foot 50-conductor extension cable (Model 14534A) is available for convenience in attaching the Pocket Programmer to the rear panel data input connector. If the Pocket Programmer is to be used, read the operating instructions in the Programmer manual before proceeding.

5-6 PERFORMANCE TEST

5-7 The following tests can be used as an incoming inspection check and appropriate portions of the test can be repeated either to check the operation of the instrument after repairs or for periodic maintenance tests. The tests are performed using a nominal 115-volt 60-Hz single-phase input supply to the unit. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to the troubleshooting procedures.

5-8 PRE-OPERATION CHECKOUT

5-9 This procedure checks the basic operation of the DVS to assure that all programming functions are operating satisfactorily.

INITIAL CONDITIONS

1. Check that the rear terminal strip is connected as shown in Figure 3-1. HI should be strapped to HI S (high sense) and LO to LO S (low sense).
2. Connect a digital voltmeter in parallel with a 200Ω ±1% 50 watt resistor across the HI and LO terminals on the rear of the DVS.
3. Connect the Pocket Programmer to the data input connector and set its switches as follows:
    a. Set the INPUT LEVEL REF switch to DATA COM.
    b. Set the MP/DCPS switch to DCPS.
    c. Set the SOURCE SELECT switch to EXT.

(The above three switches remain in these positions

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Diff. or Dig. Voltmeter	Sensitivity: 100µV full scale (min.). Accuracy: 0.004%	Measure dc voltages; calibration procedures	HP 3462, 3490, or 3420
Variable Voltage Transformer	Current Rating: 2A. Range: 90-130Vac. Equipped with voltmeter accurate within 1V.	Vary ac input	---
Oscilloscope	Differential input; dc to 50MHz	Display transient response waveforms and p-p noise	HP 180A plus 1801A, 1806A, and 1821A Plug-ins
DC Voltmeter	Accuracy: 1%, Input resistance: 20,000 ohms/volt (min.).	Measure dc voltages	HP 412A
Repetitive Load Switch	Rate: 60-400Hz, 2µsec rise and fall time.	Measure transient response	See Figure 5-5.
Resistive Loads	200Ω, 50W ±5% 20Ω, 15W ±5%	Power supply load resistors	---
Resistor	Value: 200Ω, ±1%, 50 watts.	Check current latch performance	---
Function Generator	0.0005Hz - 5MHz	Measure programming time	HP 3310A/B
DC Power Supply	0-25Vdc, 0-400mA	Provide input to ANLG IN terminals on DVS.	HP 6215A
Rms Voltmeter	10Hz-10MHz	Measure rms ripple and noise	HP 3400A
Programming Device		Supply digital program inputs	HP Pocket Programmer 14533B

throughout all of the following procedures.)

d. Set the RANGE switch to X10.

CAUTION

When operating the voltage magnitude bit switches, avoid setting them for codes greater then nine as some invalid codes will program the output voltage beyond the unit's rated maximum.

e. Set the data and sign bit switches for an output of + 0.00 volts. The proper coding for Pocket Programmer data and sign bit switches depends on the instrument being programmed. The voltage magnitude switches might either be up (open circuit) or down (grounded) to program zeros. Similarly, the OUTPUT SIGN switch might be up or down to program a positive output. Refer to the appropriate Option Appendix or the Instrument Modification Sheet supplied with the instrument being programmed for digital input coding information.)

f. Set the I LIMIT switches for a 500mA current limit.

4. Open the front access door and put the STORAGE DISABLE switch on the A2 board in the STORAGE DISABLE position.

5. Connect the line cord and switch the LINE switch to ON. The STORAGE DISABLE light will come on and the front panel meters will both indicate zero. (Select the 20V and .06A meter ranges.)

CURRENT LATCH RESET AND DISCONNECT INTERLOCK CHECK

6. On the Pocket Programmer, switch on the A8 switch (80V). Observe that the digital voltmeter indicates less than 0.3 volts (not +80.00V) and the DVS CURRENT meter reads less than 10mA. The error is because the over current latch circuit activated when the DVS was turned on.

NOTE

Whenever the DVS is turned on the Gate switch must be toggled to reset the overcurrent latch circuit.

7. Press the Pocket Programmer GATE switch. The digital voltmeter should indicate +80.00V and the DVS CURRENT meter 400mA (select meter ranges as appropriate).

8. Disconnect the Pocket Programmer data input cable. The meters will indicate 0V and less than 10mA. The instrument is in the disconnect interlock and overcurrent latch status mode.

9. Reconnect the data input cable. The meters will indicate 0V and less than 10mA. The instrument is still in the overcurrent status.

10. Press the Pocket Programmer GATE switch. The meters will indicate +80.00V and 400mA again.

VOLTAGE RANGE CHECK

11. Set the RANGE switch on the Pocket Programmer to X1. The digital voltmeter should read +8.000V.

VOLTAGE MAGNITUDE CHECK

12. On the Programmer, turn on the A1, A8, B1, B8, C1, C8, D1, and D8 switches. The digital voltmeter reading will be +9.999V ±1mV.

13. Turn off all of the voltage magnitude switches. The voltage reading will be 0 volts ±0.001 volts.

14. Set Programmer RANGE switch to X10. Turn on each voltage magnitude switch D1 through A8, individually, and check the digital voltmeter readings in the following chart (all readings ±1mV).

NOTE

Turn each bit off after making check.

15. Switch the STORAGE DISABLE switch on board A2 to the STORAGE position.

SWITCH	READING	SWITCH	READING
D1	10mV	B1	1V
D2	20mV	B2	2V
D4	40mV	B4	4V
D8	80mV	B8	8V
C1	100mV	A1	10V
C2	200mV	A2	20V
C4	400mV	A4	40V
C8	800mV	A8	80V

16. Repeat the sequence of Programmer switch operations of step (14) but press the Programmer GATE switch after each voltage magnitude bit change. Observe that the previously programmed voltage remains until the new value is gated into storage.

17. Switch the STORAGE DISABLE switch back to the STORAGE DISABLE position.

18. Set the OUTPUT SIGN switch on the Programmer to the negative position and repeat steps (14), (15), and (16).

GROSS CURRENT LIMIT

19. Turn off power to the DVS. Disconnect the 200Ω load and connect the 20Ω, 15W load across the HI and LO terminals.

20. On the DVS rear barrier strip, jumper the C_T terminals. This disables the programmable current latch circuit.

21. Set the voltage magnitude switches and OUTPUT SIGN switch on the Programmer for an output voltage of +8 volts in the X10 range.

22. Set the CURRENT METER RANGE switch on the DVS front panel to 0.6A and the STORAGE DISABLE switch on board A2 to DISABLE.

23. Turn on power to the DVS and press the Programmer GATE switch. Observe that the DVS voltmeter reads +8V.

24. While observing the DVS ammeter, increase the voltage magnitude input to +1V steps (to a maximum of +13V) until the current no longer increases (limiting). The current at limiting should be between 0.55A and 0.6A.

25. Set the voltage magnitude switches and OUTPUT SIGN switch on the Programmer for an output voltage of -8V.

26. While observing the DVS ammeter, increase the voltage magnitude input in -1V steps (to a maximum of -13V) until the current no longer increases (limiting). The current at limiting should

be between 0.55A and 0.6A.

CURRENT OVERLOAD CHECK

27. Turn off power to the DVS. Disconnect the 20Ω, 15W load and connect the 200Ω, 1%, 50 watt (minimum) load resistor between the HI and LO terminals. The jumper remains connected between the C_T terminals.

28. Check Option descriptions (Appendix A or B) or, where applicable, the Modification Sheet in the manual to determine the existence of output transistor "pull up" resistor A6A6R8. If A6A6R8 is used proceed to step 29. If A6A6R8 is not used, proceed to step 30.

29. Connect a dc voltmeter between 0 LOAD STATUS and DATA COM test points on the Pocket Programmer. Select a voltmeter range capable of reading 12 volts. Proceed to step 31.

30. Connect an ohmmeter between the 0 LOAD STATUS and DATA COM test points on the pocket programmer. The common lead should be connected to the DATA COM test point.

31. Program the current latch value for 20mA. The I LATCH (current latch) switch positions on the Programmer are listed below for the six current latch values.

32. Set the voltage magnitude and OUTPUT SIGN on the Programmer for an output voltage of +3.5V.

33. Turn on power to the DVS and press the Programmer GATE switch. Overload status signal should be normal (voltmeters should indicate the collector voltage at output stage or the ohmmeter should indicate an open circuit.

34. Increase the output voltage in 0.1V steps. Overload status signal should switch to the overload state between 3.8V and 4.2V output (voltmeter reads 0V or ohmmeter reads 0 ohms). See following chart:

CURRENT LATCH (mA)	I LATCH SWITCH POSITIONS L24	L22	L23	CURRENT OVERLOAD OCCURS BETWEEN (Volts)
20	up	up	up	3.8 and 4.2
50	up	down	up	9.5 and 10.5
70	up	up	down	13.3 and 14.7
100	up	down	down	19 and 21
200	down	up	up	38 and 42
500	down	down	up	95 and 105

35. Change the programmable current latch (I LATCH) value and output voltage at which current overload occurs to the values listed in the chart and repeat step (34).

36. Set the OUTPUT SIGN switch to negative and repeat steps (34) and (35).

CURRENT LATCH CHECK

37. Turn off power to the DVS and remove the jumper between the C_T terminals, the 200Ω load resistor remains connected between the HI and LO output terminals.

38. As in the current overload check step 28, determine the existence of the current latch output transistor "pull up" resistor A6A5R8. If A6A5R8 is used, connect a dc voltmeter between the I LATCH STATUS and DATA COM test points on the Programmer. If A6A5R8 is not used, connect an ohmmeter between these two test points.

39. On the Programmer, set the current latch (I LATCH) to 200mA and the voltage magnitude to 80.00V.

40. Turn on power to the DVS and press GATE on Programmer. Instrument should remain in current latch condition (voltmeter reads 0V or ohmmeter reads 0 ohms).

41. Remove the 200Ω load resistor from the HI and LO output terminals. Unit should remain in latched condition until a GATE signal is applied.

5-10 CONSTANT VOLTAGE TESTS

5-11 For constant voltage measurements, the measuring device must be connected across the rear sensing terminals of the supply in order to achieve valid indications. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance several orders of magnitude greater than the supply impedance (10 milliohms at dc), thus invalidating the measurement.

5-12 To avoid mutual coupling effects, each monitoring device must be connected directly to the sensing terminals by separate pairs of leads. The load resistor is connected across the output terminals and must be selected according to the output voltage and current of the supply. When measuring the constant voltage performance specifications, the CURRENT LATCH should be programmed well above the maximum output current which the supply will draw, since the onset of current latch action will cause a drop in output voltage, increased ripple, and other performance changes not properly ascribed to the constant voltage operation of the supply.

5-13 Calibration Error

Definition: The maximum absolute voltage

accuracy deviation at constant room temperature, 115Vac input, no load, following a minimum warm-up time of 30 minutes. It is the ability of the instrument to accurately convert a digital input into an analog output voltage.

5-14 To measure the accuracy, proceed as follows:

a. Connect a digital or differential voltmeter to the HI and LO sensing terminals on the rear of the unit.

b. Program the output to 99.99V and gate the unit.

c. The voltmeter should read 99.99V ±10mVdc.

d. Set the range switch to X1.

e. Program the output to -9.999 volts. Gate the input.

f. The differential voltmeter should read -9.999 ±1mVdc.

5-15 Voltmeter Accuracy. To check the accuracy of the front panel voltmeter, proceed as follows:

a. Connect a Digital or differential voltmeter to the HI and LO sensing terminals on the rear of the unit.

b. Turn on supply and program the output voltage for 99.99V. Gate the unit.

c. Record the reading on the voltmeter.

d. The reading on the front panel meter should be the same as the reading in Step (c) ±3 volts.

5-16 Load Regulation

Definition: The change ΔE_{OUT} in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-17 Load regulation should be checked in both the higher (X10) range with both negative and positive output voltages and the lower (X1) range with both positive and negative output voltages, since any one of these four conditions can yield an unsatisfactory result, which is not reflected under the other three conditions. To test the load regulation for all four conditions, proceed as follows:

a. Connect test setup shown in Figure 5-1. Set the METER switch to the highest voltage and current ranges.

b. Program the current latch to 0.5 ampere.

c. Turn on supply.

d. Program the output voltage to +99.99 volts, and gate the unit.

e. Read and record voltage indicated on voltmeter.

f. Disconnect load (open) and gate the unit.

g. Reading on voltmeter should not vary from reading recorded in Step (e) by more than $500\mu V$.

h. Reconnect load.

i. Program the output to -99.99V and gate the unit.

j. Repeat Steps (e) and (f).

k. Reading on voltmeter should not change from reading recorded in Step (e) by more than $500\mu V$.

l. Program the output to +9.999 volts. X1 range and gate the unit.

m. Change load to 20Ω, 15 watts.

n. Repeat Steps (e) and (f).

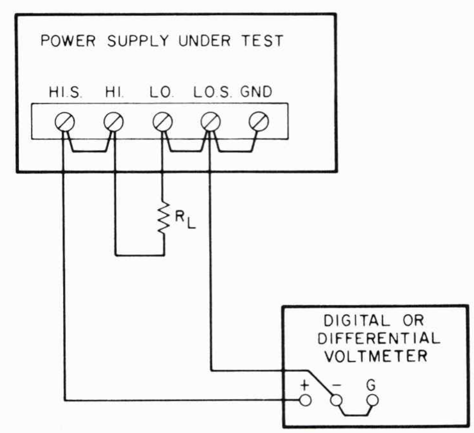
o. Reading on voltmeter should not change from the reading recorded in Step (e) by more than $150\mu V$.

p. Reconnect load (20Ω, 15W).

q. Program the output to -9.999 volts, X1 range and gate the unit.

r. Repeat Steps (e) and (f).

s. Reading on voltmeter should not change from reading recorded in Step (e) by more than $150\mu V$.



MODEL NO.	R_L (OHMS)
6128C	1.3
6129C	10
6130C	50
6131C	200

Figure 5-1. Constant Voltage Load Regulation Test Setup

5-18 Line Regulation

Definition: The change, ΔE_{OUT} in the static value of dc output voltage resulting from a change in ac input volt-

age over the specified range from low line, 10% less than nominal, to high line, 10% more than nominal, or high line to low line.

5-19 Line regulation should be checked in both the higher (X10) range with both negative and positive output voltages and the lower (X1) range with both positive and negative output voltages, since any one of these four conditions can yield an unsatisfactory result, which is not reflected under the other three conditions. To test the line regulation for all four conditions, proceed as follows:

a. Connect test setup shown in Figure 5-1. Set the METER switch to the highest voltage and current ranges.

b. Connect variable auto transformer between input power source and power supply 115Vac input.

c. Strap C_T terminals together.

d. Program the output voltage to 99.99 volts.

e. Program the output voltage sign to positive (+).

f. Adjust variable auto transformer for an ac input 10% less than nominal. Gate the unit.

g. Read and record voltage indicated on voltmeter.

h. Adjust variable auto transformer for an ac input 10% more than nominal. Gate the unit.

i. Reading on differential voltmeter should not vary from reading recorded in Step (g) by more than 4mV.

j. Program the output voltage sign to negative (-). Perform Steps (f) through (i).

k. Program the output voltage to 9.999Vdc, X1 range. Change R_L to 20Ω, 15W.

l. Program the output voltage sign to positive (+). Perform Steps (f) through (h).

m. The reading on the voltmeter should not vary from the reading recorded in Step (g) by more than 400µV.

n. Program the output voltage sign to negative (-). Perform (f) through (h).

o. The reading on the voltmeter should not vary from the reading recorded in Step (g) by more than 400µV.

5-20 Temperature Coefficient
Definition: The change in output voltage per degree Centigrade change in the ambient temperature under conditions of constant input ac line voltage, output voltage setting, and load resistance.

5-21 The temperature coefficient of a power supply is measured by placing the power supply in an oven and varing the temperature over any span within its rating. (Most HP power supplies are rated for operation from 0°C to 55°C.) The power supply must be allowed to thermally stabilize for a sufficient period of time at each temperature of measurement, usually 1/2 hour.

5-22 To check the temperature coefficient, proceed as follows:

a. Connect test setup shown in Figure 5-1.

b. Strap C_T terminals and program the output voltage to 99.99 volts. Gate the unit.

c. Insert the power supply into the temperature-controlled oven (voltmeter and load resistance remain outside oven). Set the temperature to 30°C and allow 30 minutes warm-up.

d. Record the voltmeter indication.

e. Raise the temperature to 40°C and allow 30 minutes warm-up.

f. The voltmeter indication should change by less than 10mV from indication recorded in Step (d).

g. Program the output voltage to 9.999 volts. Gate the unit. Change R_L to 20Ω, 15W. Perform Steps (c) through (e).

h. The voltmeter indication should change by less than 1mV from indication recorded in Step (d).

5-23 Programming Time
Definition: Maximum time required for the output voltage to settle to within 0.1% of the programmed voltage change after simultaneous receipt of the data and gate commands as measured with a resistive load.

5-24 To check the programming time connect the test setup as shown in Figure 5-2 and proceed as follows:

CONTROL SETTINGS

a. Set switches on HP 3490A as follows:
1. FUNCTION: DC
2. RANGE: As needed 10V or 100V
3. SAMPLE RATE: HOLD

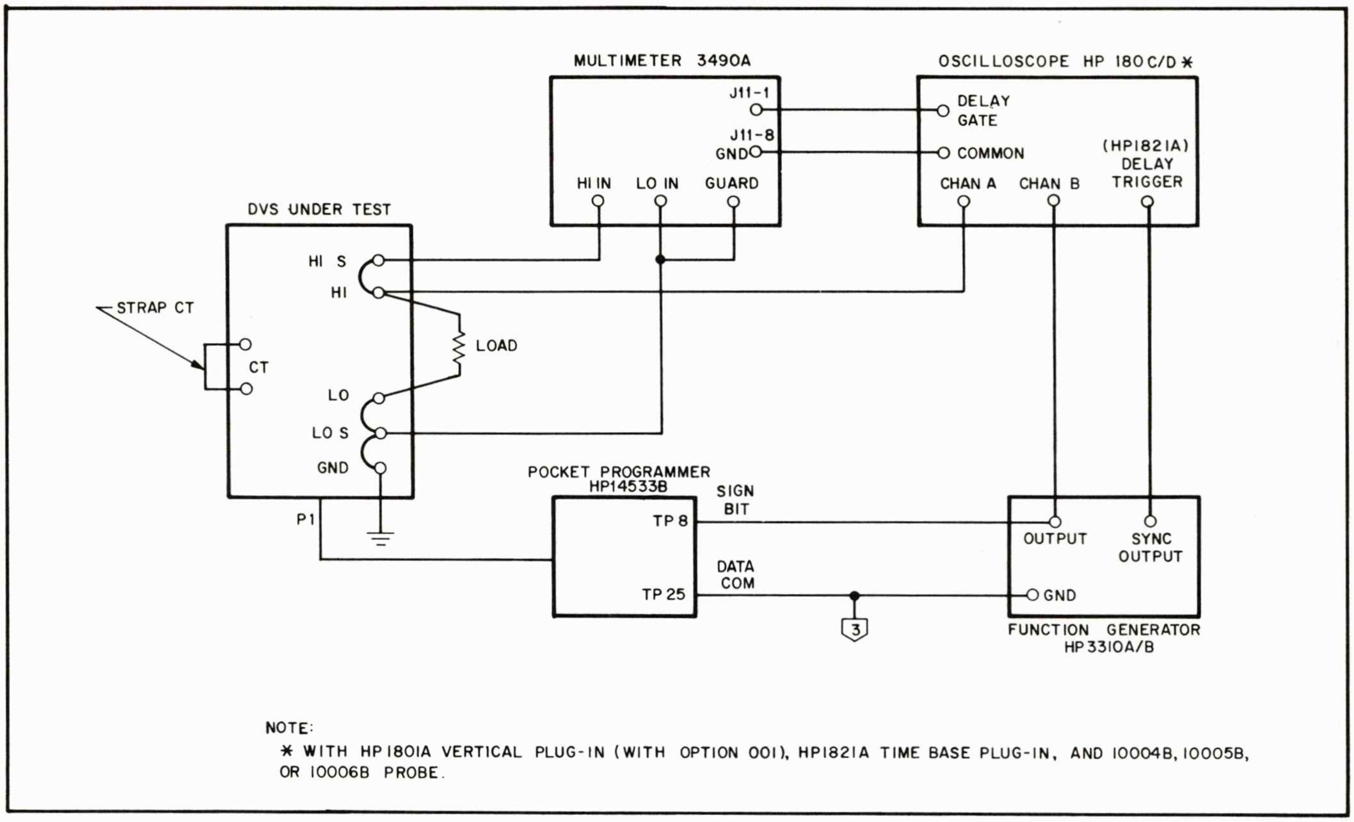


Figure 5-2. Programming Time Test Setup

4. SAMPLE/HOLD: TRACK/HOLD

b. Set switches on HP 1821A Delay Section of HP 180 C/D as follows:

1. AC or ACF: SLOPE + or -; AUTO
2. TRIGGER LEVEL: Adjust for stable display
3. TIME/DIV: Delayed to 0.1 to 0.5μsec

c. Set HP 1821A Main Section of HP 180 C/D as follows:

1. SWEEP MODE: AUTO
2. INT: SLOPE + or -; AC
3. TIME/DIV: 1msec with X10 magnifier
4. Set sweep to MAIN

d. Set switches on HP 3310 A/B as follows:

1. FREQUENCY: 100Hz
2. FUNCTION: Squarewave
3. OUTPUT LEVEL: Value specified in DVS Appendix for data and sign bits.

e. Set switches on HP 14533B as follows:

1. SOURCE SELECT: EXT
2. MP/DCPS: DCPS
3. I LATCH: 500mA (L22 down, L23 up, L24 down)
4. INPUT LEVEL REF: DATA COM
5. RANGE: X1

f. On DVS A2 board, set switch to STORAGE DISABLE (only if Pocket Programmer is used).

PROCEDURE

a. Connect 200Ω, 50W load between HI and LO output terminals and strap C_T terminals together on rear of DVS.

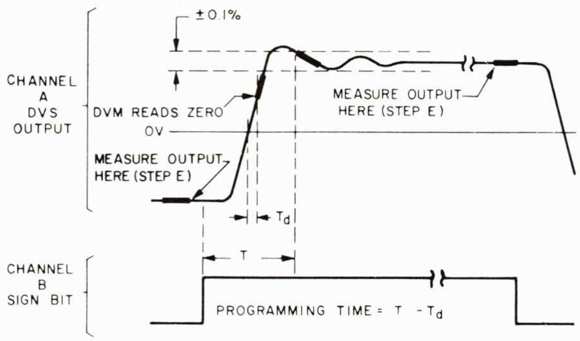
b. On the Pocket Programmer, switch the OUTPUT SIGN switch to the up (OPEN CIRCUIT) position to permit using input jack TP8, select the X10 range and program a 99.99V output.

c. Turn on the DVS and gate it. The function generator will program the DVS between plus and minus 99.99 volts at a 100Hz rate. The DVS sign bit will be displayed on channel B and the DVS output voltage on channel A. Adjust the DELAYED TRIGGER LEVEL for a stable display. A portion of both traces will be brightened. The start of the brightened portion represents the point on the DVS output waveform that the multimeter will read, and can be moved along the trace by adjusting the DELAY (DIV) control on the 1821A.

d. To calibrate the system delay, adjust the DELAY (DIV) control until the 3490A reads approximately zero volts. The time between the actual zero crossing of the DVS output (channel A) and the start of the bright spot indicates system delay (T_d).

e. Measure the voltage just prior to the waveform transitions (see Figure 5-3). Voltage reading should be within 0.1% of ΔV_{OUT}. Note that ΔV_{OUT} is two times 99.99V or about 200V. The output voltage should be within 0.1% (or 0.2V) of this value within 300 microseconds.

f. Read the DVS output voltage after it has become fully settled by moving the start of the



RANGE	PROGRAMMING TIME
X1	< 300μ SEC
X10	< 300μ SEC

Figure 5-3. Programming Time Waveforms

bright spot to a point on the flat top of the output waveform near the right-hand edge. Note the reading on the 3490A, which should be 99.99V.

g. Now, slowly move the bright spot to the left while watching the 3490A indication. The first point at which the reading changes by 0.1% from the reading made in step (e) is the point after which the output voltage remains within a ±0.1% tolerance band. Programming Time is therefore the time between this point (less T_d) and the transition time of the channel B trace (see Figure 5-3).

h. Program the voltage range to X1 and voltage output to 9.999V. Using a 20Ω, 15W load, repeat steps (c) through (h).

5-25 Ripple and Noise

Definition: The residual ac voltage which is superimposed in the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS or (preferable) peak-to-peak value.

Ripple and noise measurement can be made at any input ac line voltage combined with any dc output voltage and load current within rating.

5-26 The amount of ripple and noise that is present on the power supply output is measured either in terms of the RMS or (preferable) peak-to-peak value. The peak-to-peak measurement is particularly important for applications where noise spikes could be detrimental to a sensitive load, such as logic circuitry. The RMS measurement is not an ideal representation of the noise, since fairly high output noise spikes of short duration could be present in the ripple and not appreciably increase the RMS value.

5-27 RMS Measurement. To check the rms value of ripple and noise, proceed as follows:

a. Connect 200Ω, 50W load across HI and LO terminals.

b. Using coax cable, connect rms voltmeter (HP 3400A is recommended) to the DVS HI and LO terminals. On the DVS end, connect the coax inner conductor to the HI terminal and the coax shield lead to the LO terminal (which is also connected to DVS ground).

c. Strap C_T terminals together.

d. Program the output voltage for 99.99 volts and the voltage range to X10.

e. The voltmeter should read less then 1.5mV rms.

f. Program the voltage range to X1 and output voltage to +9.999 volts. Change load to 20Ω, 15W.

g. The voltmeter should read less than 0.5mV rms.

5-28 Note that a continuous ground loop exists from the third wire of the input power cord of the rms meter via the grounded power supply case, the wire between the negative output terminal of the power supply and the input of the meter, and the grounded meter case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the meter input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the leads interconnecting the power supply and meter, appears in the meter reading. The magnitude of this resulting noise signal can easily be much greater than the true ripple developed between the output terminals of the power supply, and can completely invalidate the measurement. To minimize the effects of ground current flow, the DVS and test instruments in all ripple and noise measurements should be plugged into the same ac power bus whenever possible.

5-29 Peak-to-Peak Measurements. The same ground current and pickup problems exist if an oscilloscope is substituted in place of the rms voltmeter in the peak-to-peak measurements. However, the oscilloscope display, unlike the true rms meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an HP supply is 120Hz (due to full-wave rectification), an oscilloscope display showing a 120Hz fundamental com-

ponent is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple. To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (-) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-30 The simple, direct test equipment connection of the rms measurement is normally not adequate to measure the high-frequency components of the peak-to-peak ripple and noise. Figure 5-4A shows a technique using a 50Ω coaxial cable between the DVS and oscilloscope that is terminated in its characteristic impedance. Note that the terminating network is placed across the DVS output to avoid attenuating the low-frequency (60Hz) component of the ripple and noise. Further, the impedance matching network eliminates standing waves and cable ringing which might introduce erroneous values in the measurement.

5-31 In most cases, the single-ended scope method of Figure 5-4A will be adequate to eliminate non-real components of ripple so that a satisfactory measurement may be obtained. However, if the DVS and oscilloscope cannot be plugged into the same ac power buss or the peak-to-peak reading obtained with a single ended scope exceeds the specifications due to I_S, it will be necessary to use a differential scope with properly terminated floating inputs as shown in Figure 5-4B. Note that the coax connectors are not connected to ground on the DVS end. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal produced by the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, then the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-32 To check the peak-to-peak ripple and noise output, proceed as follows:

a. Connect 200Ω, 50W load, impedance matching network(s), and oscilloscope as shown in Figures 5-4A or 5-4B.

b. Strap together C_T terminals.

c. Program the output voltage for 99.99 volts.

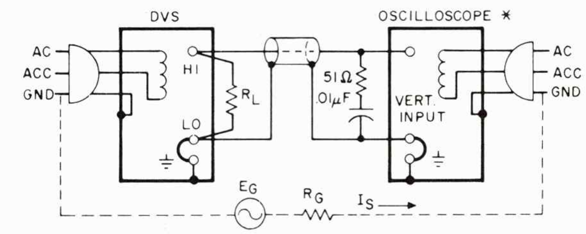
d. The observed ripple should be less than 7mV p-p.

e. Program the voltage range to X1, the output voltage to +9.999 volts, and change load to 20Ω, 15W. The observed ripple should be less than 2mV p-p.

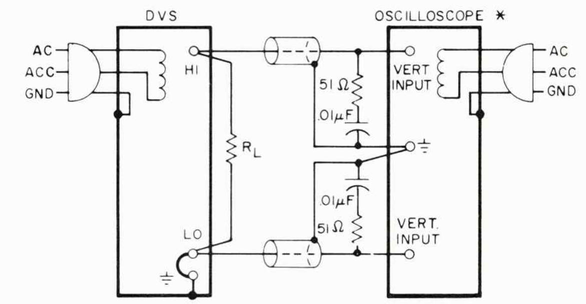
5-33 Transient Recovery Time

Definition: The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current—where: "Y" is specified as 0.1% of full range voltage. The nominal output voltage is defined as the dc level half way between the static output voltage before and after the imposed load change, and "Z" is the specified load current change, which is equal to the rated output current.

5-34 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-5 should be used for loading and unloading the supply. When this



A. METHOD USING A SINGLE-ENDED SCOPE PROPERLY TERMINATED. NOTE THAT GROUND CURRENT I_S MAY CAUSE ERRONEOUS RESULTS. BOTH DVS AND OSCILLOSCOPE SHOULD BE PLUGGED INTO SAME AC POWER BUSS TO MINIMIZE GROUND CURRENT. IF P-P SPECIFICATION EXCEEDED DUE TO I_S USE METHOD B.



B. METHOD USING A DIFFERENTIAL SCOPE WITH FLOATING INPUT. GROUND CURRENT PATH IS BROKEN; COMMON MODE REJECTION OF DIFFERENTIAL INPUT SCOPE IGNORES DIFFERENCE IN GROUND POTENTIAL OF DVS AND SCOPE.

* HP180 OSCILLOSCOPE WITH: 1801A VERTICAL PLUG-IN (WITH OPTION 001), 1821A TIME BASE PLUG-IN, AND TWO 10007B PROBES.

Figure 5-4. Peak-to-Peak Ripple and Noise Test Setup

load switch is connected to a 60Hz ac input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25K control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display.

5-35 The maximum load ratings listed in Figure 5-5 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

5-36 The transient recovery time is checked in both the X10 and X1 ranges as follows:

a. Connect test setup shown in Figure 5-5.

b. Strap C_T terminals together.

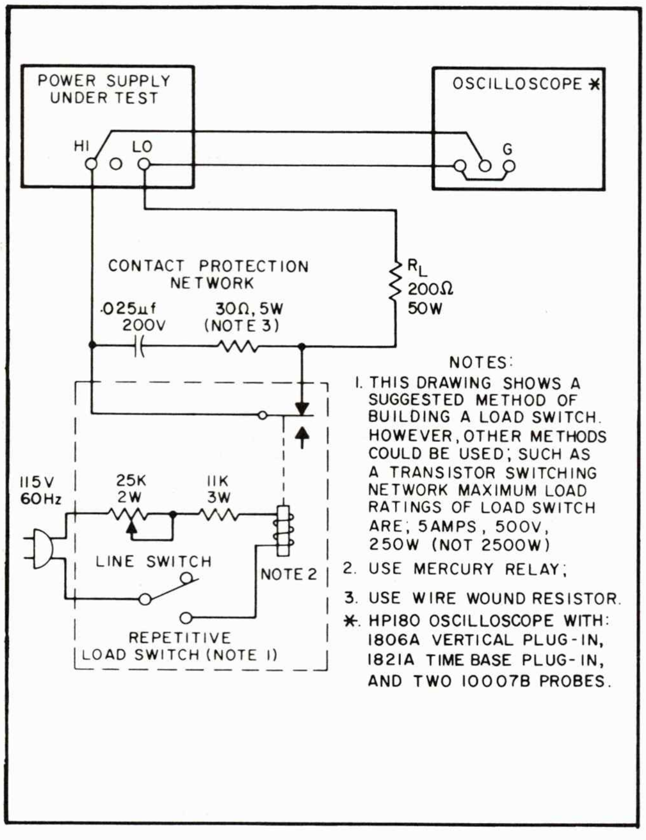


Figure 5-5. Transient Recovery Time, Test Setup

c. Turn on supply and program the output voltage to +99.99 volts.

d. Close the line switch on the repetitive load switch setup.

e. Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.

f. Set the vertical input of the oscilloscope for ac coupling so that small dc level changes the output voltage of the power supply will not cause the display to shift.

g. Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.

h. Starting from the major graticule division representative of time zero, count to the right 150 µsec and vertically 100mV. Recovery should be within these tolerances as illustrated in Figure 5-6.

i. Program the output voltage to +9.999 volts, change R_L to 20Ω, 15W and the voltage range to X1.

j. The transient recovery should be within 10mV at 150µsec as illustrated in Figure 5-6.

5-37 TROUBLESHOOTING

5-38 Before attempting to troubleshoot this instrument, make certain that the trouble lies within the instrument and not in any associated equipment. In order to isolate the DVS from the system in which it is being used, the HP Pocket Programmer 14533B is recommended. This device permits the operator to manually program all functions of the DVS and thus isolate it from other possible sources of trouble within the system, such as computer interfacing or a programming error.

5-39 A good understanding of the principles of operation of the instrument is essential to an efficient approach to troubleshooting. For this

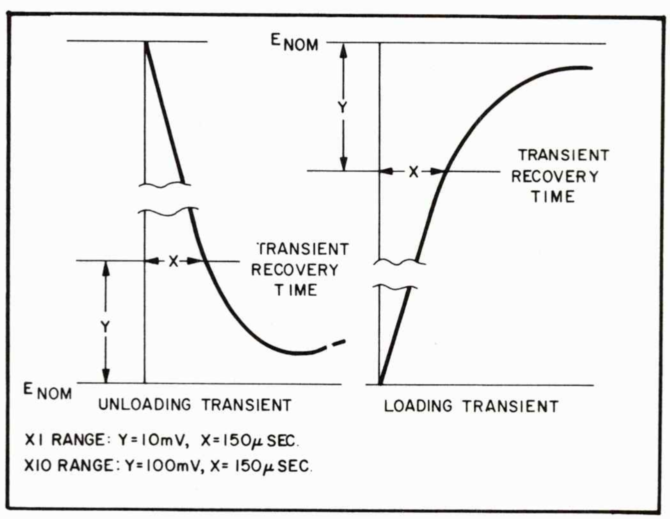


Figure 5-6. Transient Recovery Time, Waveforms

reason it is recommended that Section IV, Principles of Operation be reviewed before attempting to troubleshoot the unit. Once the principles of operation are understood, follow the steps of the Overall Trouble Isolation Procedure in paragraphs 5-43 through 5-46 in the given order to establish which circuit areas are functional and which are not. References to more detailed troubleshooting guides are given in that procedure.

5-40 The four sheets of schematic diagrams of Figure 7-2 are based on the functional organization of the unit. Figure 7-1 provides an overall block diagram of the unit, except for its power distribution, and is especially convenient for tracing signal flow through the entire instrument. The circled test point numbers on Figures 7-1 and 7-2 are also marked on the component location diagrams which accompany the schematics. References are made to these test points in the Principles of Operation section of the manual, as well.

5-41 Before proceeding with the trouble isolation procedure, check for obvious troubles such as an open fuse, a defective power cord, an input power failure, a defective meter or a loosely connected board. Next visually inspect the boards for mechanical damage discolored or charred components, etc. If the source of trouble cannot be detected by visual inspection perform the Overall Trouble Isolation Procedure given below. Throughout the course of troubleshooting the instrument, do not neglect the possibility of two or more faults being present.

CAUTION

Trouble isolation by exchanging a known good board for a suspected faulty one is allowed only for the A1, A2, and A3 boards. Exchanging a good board for a faulty one in any of the other card slots will often result in causing damage to the good board.

5-42 OVERALL TROUBLE ISOLATION PROCEDURE

5-43 Trouble Isolation — Power Distribution. Almost any trouble sympton could be caused by an incorrect power supply or reference voltage, thus it is good practice to routinely check all of the most important power supply voltages before attempting to isolate a problem to a particular circuit. The tests described in Table 5-2 provide a relatively fast check for trouble in this area. In many cases these checks can save hours that might be spent troubleshooting circuits which are not themselves defective. The A4 power supply board test points are accessible by removing the top cover; the A7 power amplifier test points are accessible by installing the extender board/A7 combination in the A7 slot. The test points are located by referring to the component location diagrams.

5-44 Notice that there are four separate power supply common return systems in the DVS, designated common 1 , common 2 , common 3 and common 4 . When making any voltage or waveform measurements, be sure to use the appropriate power supply common reference point. The appropriate common point can be determined by referring to the circuit schematics of Figure 7-2. If the supply voltages are correct or if the supply voltages are incorrect but the components in that supply are not defective, proceed to paragraph 5-45.

5-45 Overall Troubleshooting Table. After checking the power supplies, disconnect the load and examine Table 5-3. This table contains a list of symptoms and probable causes that may cut down on troubleshooting time. For each trouble symptom, Table 5-3 isolates the fault to a component or group of components or directs the reader to additional procedures if further isolation of the trouble is necessary.

Table 5-2. Power Supply Troubleshooting

METER COMMON	METER POSITIVE	NORMAL READING	MAXIMUM RIPPLE P-P	PROBABLY DEFECTIVE COMPONENT
3	TP84	12 ± 1.5Vdc	0.2V	A4C1, CR2, CR3 or R1
TP85	3	12 ± 1.5Vdc	0.6V	A4C2, CR1, CR4, or R2
TP86	3	10 ± 2.0Vdc	0.6V	A4C10, CR22, CR5, CR6 or R26
4	TP87	5.0 ± .25Vdc	5mV	A4C3, CR8, CR9, R3, A5C2, C3, or Z1
2	TP88	26 ± 4Vdc	1.2V	A4C4, C19, C21, CR10, CR12 or R4
TP89	2	26 ± 4Vdc	0.8V	A4C5, C20, C22, CR11, CR13 or R5
1	TP90	155 ±31Vdc	0.25V	A4C8, C12, C13, CR15, CR20, or R8
TP93	1	155 ±31Vdc	0.25V	A4C9, C11, C14, CR14, CR21 or R9
1	TP91	140 ±14Vdc	0.8V	A4C6, C15, C18, CR16, CR19 or R6
TP92	1	140 ±14Vdc	0.8V	A4C7, C16, C17, CR17, CR18 or R7
NOTE: Test points 94 and 95 are on A7.				
2	TP94	15 ± 0.2V	0.0015V	A7C25, Q26, Q27, VR5 or CR24
TP95	2	15 ± 0.2V	0.0015V	A7C24, Q28, Q29, VR6 or CR25

Table 5-3. Overall Troubleshooting

SYMPTOM	PROBABLE CAUSE
Zero or Low Output Voltage	a. Fuse blown. Check output power transistors. b. Defective meter. c. Board(s) loosely connected. d. A4Q1 open or A4K1 defective. A4CR7 shorted. e. Short circuit load. f. Interconnect board A5 open.

Table 5-3. Overall Troubleshooting (Continued)

SYMPTOM	PROBABLE CAUSE
Zero or Low Output Voltage (Continued)	g. Input connector P1 loosely connected h. Defective board or unit in latch (paragraph 5-46)
Unable to program output voltage or actual output does not coincide with programmed input	a. Meter circuit defective. b. Flag or gate pulse not generated (paragraph 5-57). c. Voltage bits out of calibration (paragraph 5-71). d. Defective board (paragraph 5-46).
Able to program only a few voltages of each polarity	a. Defective board (paragraph 5-46).
Able to program at least some negative output voltages within the rating of the supply but no positive output voltages	a. Sign bit circuit defective (paragraph 5-47).
Able to program at least some positive output voltages within the rating of the supply but no negative output voltages	a. Sign bit circuit defective (paragraph 5-47).
Able to program all but a few voltages of each polarity	a. Voltage Processing circuits defective (paragraph 5-47).
Programmable current latch defective or unable to get unit into or out of current latch	a. A6 or A7 boards defective (paragraph 5-46).
Unit locked up (high positive output) or locked-down (high negative output)	a. Defective A7 board (paragraph 5-64)
Flag or gate pulse not being generated	a. Defective A1 board (paragraph 5-47).
Unable to program voltage range	a. A7K1 defective b. Defective A6 board (paragraph 5-55).
Programmable current latch defective (unable to program some values	a. Defective A6 board (paragraph 5-55).

Table 5-3. Overall Troubleshooting (Continued)

SYMPTOM	PROBABLE CAUSE
Poor Line Regulation	a. Power supplies faulty. b. Marginal photo-isolators on board A1 (paragraph 5-53).
Poor Load Regulation	a. Power Supplies faulty. b. Excessive voltage drop in sensing leads.

5-46 Board Isolation Procedure. The board isolation procedure describes how to isolate trouble to the power amplifier board A7, the control board A6, or to the voltage processing boards A1, A2, and A3. When the defective board(s) is located, further isolation is necessary before the trouble can be traced down to a particular circuit or component. Paragraphs 5-47 through 5-68 describe troubleshooting procedures on individual boards which isolate the trouble down to a component or circuit. The board isolation procedure assumes that an output voltage problem (zero or incorrect output voltage) exists. To isolate troubles to the defective board(s) proceed as follows:

1. Remove boards A2 and A3 from the DVS.
2. Remove load and connect voltmeter across HI and LO output terminals.
3. Connect Pocket Programmer to the data input connector and set its switches as follows:
   a. Set the INPUT LEVEL REF switch to DATA COM
   b. Set the SOURCE SELECT switch to EXT.
   c. Set the MP/DCPS switch to DCPS.
   d. Set the RANGE switch to X10.
   e. The voltage magnitude bit switches, OUTPUT SIGN switch and I LATCH switches (L24, L22, and L23) may be left on either position (up or down) at this point in the procedure.
4. Turn on power apply a GATE pulse to the DVS and measure output voltage. Output should be 0 volts ± 10mV. If output is not correct, troubleshoot the power amplifier board A7 (paragraph 5-64).
5. Connect a negative dc voltage ($-V_x$) between the ANLG IN and LO S terminals on the rear of the DVS. Connect (-) polarity to the ANLG IN terminal and (+) polarity to the LO S terminal as shown in Figure 5-7A. Note that the power amplifier in the DVS inverts this voltage and amplifies it by 1 in the X1 range and by 10 in the X10 range. The magnitude of the V_x input (maximum of 10V in the X10 range) depends upon the trouble encountered. For example, if a high range output voltage cannot be programmed, apply a high range voltage to the analog input.

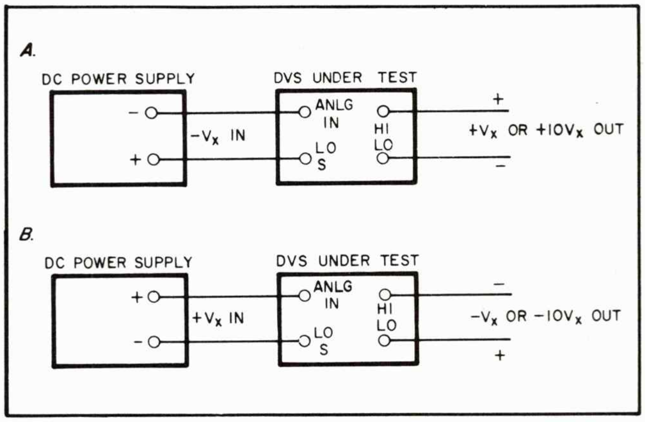


Figure 5-7. DVS Analog Input Connections

6. Measure the output voltage. Output should be $+10V_x$ ±0.2%. If output is $+10V_x$ ±0.2%, proceed to step 7. If output is $+V_x$ ±0.2%, the problem is in the range circuits on board A6 (paragraph 5-61) or the range relay A7K1 is defective. If the output is not $+10V_x$ ±0.2% or $+V_x$ ±0.2% troubleshoot the A7 board (paragraph 5-64).
7. Connect a positive dc voltage ($+V_x$) between the ANLG IN and LO S terminals as shown in Figure 5-7B. Set the RANGE switch on the Programmer to X1.
8. Measure the output voltage. Output should be $-V_x$ ± 0.2%. If output is $-V_x$ ± 0.2%, proceed to step 9. If output is $-10V_x$ ± 0.2%, the problem is in the range circuits on board A6 (paragraph 5-61) or the range relay A7K1 is defective. If output is not $-V_x$ ± 0.2% or $-10V_x$ ±0.2%, troubleshoot the A7 board (paragraph 5-64).
9. Turn off DVS and make the following test setup changes:

a. Remove the A7 board and install it with the extender board (side A, position D) in the A7 slot.

b. Connect a 200Ω load in parallel with the voltmeter across the HI and LO output terminals.

c. Connect $-V_X$ to ANLG IN as shown in Figure 5-7A.

10. Turn on DVS and measure output. Output should be less than 1 volt because the DVS should be in the latch condition. If output is less than 1V, proceed to step 12. If output is $+V_X$ (DVS is not in latch condition), proceed to step 11.

11. Measure the voltage across A7R92 (connect positive probe to base of A7Q25 and negative probe to 2) see Figure 7-2, sheet 3. If meter reads approximately +0.7 volts (one V_{BE} drop), the A7 latch circuit is defective (see paragraph 5-67). If meter reads less than one V_{BE} voltage drop, the A6 latch circuit is defective (see paragraph 5-58) provided A7Q25 is not shorted from base to emitter.

12. Apply a GATE pulse via the Pocket Programmer (14533B) to get the DVS out of the latch condition.

13. Measure output voltage. Output voltage should be $+V_X$. If output is less than $+V_X$, the A7 latch circuits are defective (see paragraph 5-67).

14. Connect $+V_X$ to ANLG IN as shown in Figure 5-7B and measure the output voltage. Output voltage should be $-V_X$. If output is between zero and $-V_X$, the A7 latch circuits are defective (see paragraph 5-67).

15. Turn off the DVS and make the following test setup changes:

a. Remove A7/extender board and return A7 to its slot.

b. Insert the A2 board in its slot.

c. Install A3 with extender board (side A, position A) in the A3 slot.

d. Remove the input from the ANLG IN and LO S terminals.

e. On the Pocket Programmer, set voltage magnitude switches for an output of +99.99V.

16. Turn on DVS. On the A3 board, check voltages at TP52 (+16V ±1%), TP53 (-10V ±1%), and TP55 (21.5V ±5%). All voltages should be within tolerance. If not, check the associated regulating circuit on the A3 board.

17. On the Pocket Programmer, set all voltage magnitude switches to the off position (0V output).

18. Check voltages at TP52, TP53, and TP55 on the A3 board. Voltage changes should be as indicated below. If not, check associated regulating circuit on the A3 board. If voltages check out, perform the troubleshooting procedures for the voltage processing circuits (paragraph 5-47).

TP	ΔV
TP52	±0.5mV
TP53	±0.5mV
TP55	±100mV

5-47 VOLTAGE PROCESSING CIRCUIT TROUBLESHOOTING

5-48 The following paragraphs should be helpful in locating any circuit failures on the A1, A2, or A3 boards. Paragraph 5-49 traces the voltage magnitude and sign bits through the three boards to locate data bit problems on the A1 and A2 boards or to isolate them to the A3 board. Paragraph 5-50 troubleshoots the A3 board in detail. Paragraph 5-51 troubleshoots the gate, flag, and storage strobe circuits on the A1 and A2 boards. Refer to Figure 7-2, sheet 1 when troubleshooting circuit failures on the A1, A2, or A3 circuit boards. Use the extender board (paragraph 5-4) to gain access to circuit board test points.

NOTE

For convenience, it is best to leave the A6 and A7 boards out of the unit while troubleshooting the voltage processing circuits.

5-49 A1 and A2 Board Troubleshooting. Assuming that the sign bit or one or more voltage magnitude bits do not affect the output of the D/A converter, the following steps will isolate the problem to a particular board.

a. Observe the voltage between common 3 and A1TP10 of the bit to be tested. Toggle the input bit. There should be two logic levels at TP10. If there are not, look for a problem in the programming source or its connector, in the A1 board connector, or in the input bias circuit.

b. Toggle the input bit while observing the voltage between common 4 and A1TP13. There should be two logic levels. If the voltage is zero, check for an open A1 or A2 board connector or an open resistor in A2Z5 or A2Z6. If the voltage remains near zero or about 5 volts, the problem is on the A1 board, either in the input bias circuit or the isolator circuit. For isolator circuit troubleshooting instructions, see paragraph 5-53.

c. To check for problems on the A2 board, switch to STORAGE DISABLE and check the voltage between A2TP97 (or A2TP51, for the sign bit) and common 4 while toggling the associated input bit. If there are not two logic levels, the storage IC is probably defective. But first check for a high logic level at A2TP9. If this level is low a storage disable circuit fault is indicated; see paragraph 5-51.

d. If TP97 does exhibit two levels, check

for two levels at TP106 of the corresponding bit(s), but do so with a negative output programmed so that the nines complement logic does not complement the input.

e. To aid in the further troubleshooting of the nines complement logic, if this is required, Tables 5-4 and 5-5 are provided. These tables list the logic levels at all pertinent nodes within the nines complement logic for all valid input codes, positive and negative, respectively. To use these tables in troubleshooting, simply program 0 (0000) through 9 (1001) for the digit which seems to be faulty (using both positive and negative polarities) until an improper output appears at TP106. A logical "one" is a high at TP97 and at TP106. When an improper output occurs, find the programmed input at the top of Table 5-4 or 5-5, and then read down the column and monitor the logic levels at the circuit points described in the left-hand column. When a pin is found that has a wrong logic level, the fault may be assumed to be the output of the IC whose output is being measured or the input of the next IC.

f. If the outputs of the A2 board are normal but the unit will not pass the trouble isolation tests of paragraph 5-46, the A3 board may be assumed to be at fault.

5-50 A3 Board Troubleshooting. If a problem has been isolated to the A3 board, first check the three voltages that are regulated on that board. (All

Table 5-4. Nines Complement Troubleshooting (Positive Sign Programmed)

INPUT (TP97)	+0 0000	+1 0001	+2 0010	+3 0011	+4 0100	+5 0101	+6 0110	+7 0111	+8 1000	+9 1001
Z5 PIN 8	HI	HI	HI	HI	HI	HI	HI	HI	LO	LO
Z5 PIN 6	HI	HI	HI	HI	LO	LO	LO	LO	HI	HI
Z3 PIN 11	HI	HI	LO	LO	HI	HI	LO	LO	HI	HI
Z2 PIN 8	HI	LO	HI	LO	HI	LO	HI	LO	HI	LO
Z3 PIN 6	LO	LO	HI	HI	HI	HI	HI	HI	LO	LO
Z5 PIN 11	HI	HI	LO	LO	LO	LO	LO	LO	HI	HI
Z5 PIN 3	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z6 PIN 8	LO	LO	HI	HI	HI	HI	HI	HI	HI	HI
Z3 PIN 8	HI	HI	HI	HI	LO	LO	HI	HI	HI	HI
Z3 PIN 3	HI	HI	LO	LO	HI	HI	HI	HI	HI	HI
Z6 PIN 6	HI	HI	LO	LO	LO	LO	LO	LO	LO	LO
Z4 PIN 8	LO	LO	HI	HI	HI	HI	LO	LO	LO	LO
Z2 PIN 13	LO	LO	LO	LO	LO	LO	LO	LO	LO	LO
Z2 PIN 4	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z6 PIN 11	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z6 Pin 3	LO	LO	HI	HI	HI	HI	HI	HI	HI	HI
Z4 PIN 11	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z4 PIN 6	HI	HI	LO	LO	LO	LO	HI	HI	HI	HI
Z2 PIN 11	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z2 PIN 6	LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
Z4 PIN 3	LO	LO	HI	HI	HI	HI	LO	LO	LO	LO
Z2 PIN 3	HI	LO	HI	LO	HI	LO	HI	LO	HI	LO
Z1 (PIN 3, 6, 8, or 11)	HI	HI	LO	LO	LO	LO	LO	LO	LO	LO
OUTPUT (TP106)	9 1001	8 1000	7 0111	6 0110	5 0101	4 0100	3 0011	2 0010	1 0001	0 0000

Table 5-5. Nines Complement Troubleshooting (Negative Sign Programmed)

INPUT (TP97)	-0 0000	-1 0001	-2 0010	-3 0011	-4 0100	-5 0101	-6 0110	-7 0111	-8 1000	-9 1001
Z5 PIN 8	HI	HI	HI	HI	HI	HI	HI	HI	LO	LO
Z5 PIN 6	HI	HI	HI	HI	LO	LO	LO	LO	HI	HI
Z3 PIN 11	HI	HI	LO	LO	HI	HI	LO	LO	HI	HI
Z2 PIN 8	HI	LO	HI	LO	HI	LO	HI	LO	HI	LO
Z3 PIN 6	LO	LO	HI	HI	HI	HI	HI	HI	LO	LO
Z5 PIN 11	HI	HI	LO	LO	LO	LO	LO	LO	HI	HI
Z5 PIN 3	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z6 PIN 8	LO	LO	HI	HI	HI	HI	HI	HI	HI	HI
Z3 PIN 8	HI	HI	HI	HI	LO	LO	HI	HI	HI	HI
Z3 PIN 3	HI	HI	LO	LO	HI	HI	HI	HI	HI	HI
Z6 PIN 6	HI	HI	LO	LO	LO	LO	LO	LO	LO	LO
Z4 PIN 8	LO	LO	HI	HI	HI	HI	LO	LO	LO	LO
Z2 PIN 13	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z2 PIN 4	LO	LO	LO	LO	LO	LO	LO	LO	LO	LO
Z6 PIN 11	HI	HI	HI	HI	HI	HI	HI	HI	LO	LO
Z6 PIN 3	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z4 PIN 11	HI	HI	HI	HI	LO	LO	LO	LO	HI	HI
Z4 PIN 6	H	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z2 PIN 11	HI	LO	HI	LO	HI	LO	HI	LO	HI	LO
Z2 PIN 6	HI	HI	HI	HI	HI	HI	HI	HI	HI	HI
Z4 PIN 3	LO	LO	LO	LO	HI	HI	HI	HI	LO	LO
Z2 PIN 3	LO	HI	LO	HI	LO	HI	LO	HI	LO	HI
Z1 (PIN 3, 6, 8, or11)	LO	LO	LO	LO	LO	LO	LO	LO	HI	HI
OUTPUT (TP106)	0 0000	1 0001	2 0010	3 0011	4 0100	5 0101	6 0110	7 0111	8 1000	9 1001

voltage measurements on A3 are referenced to common [2] .)

a. Measure the outputs of the +21.5-volt, +16-volt, and -10-volt supplies at test points TP55, TP52, and TP53. If any of these voltages is not within 5% of the nominal value, check the requlating circuit for that particular voltage. Note that a shorted switching transistor (Q2 or Q3) can affect the +16-volt reference. If one of these two switching transistors is shorted, either a high or low, input respectively to Q1 will load down the positive reference through Q2 and Q3 in series. A Q2 or Q3 short can be detected by monitoring the +16-volt regulator output while toggling each input bit.

b. Program all voltage magnitude input bits to produce low inputs at the base of Q1 and measure the voltage at TP54 of each bit. The voltage at TP54 should be between zero and + 8mV. If any bit is higher than + 8mV, check Q1 and Q3.

c. Now program for high inputs at the base of A1 and again measure the voltage at TP54 of each bit. All bits should be within 8mV of TP52 voltage. If any are lower than this voltage, check Q1 and Q2.

d. If all ladder network switching circuits are now operating properly, the voltage at TP54 of each bit can be alternated between the values specified above by toggling the input bit.

e. If the sign bit tested good at A2TP51 but does not affect the output of the A3 board, check transistors A3Q13 and A3Q14 in the polarity offset switch. A failure either here or in the -10-volt reference supply is likely.

NOTE

If any repair or adjustment of the power amplifier is required, that will have to be completed before the D/A converter can be performance tested or calibrated.

f. If steps (a) through (e) above confirm the proper operation of the A3 board voltage regulators, bit switches, and polarity offset switch, the only possible trouble area remaining on the D/A board is the resistive ladder network. An out-of-tolerance resistor in the ladder network will be detected only by attempting to calibrate the unit. Perform the calibration procedure of paragraph 5-71. If one or more bits cannot be calibrated, their identity should pinpoint the faulty resistor(s). If the -10-volt reference supply and polarity offset switch are operating but the polarity offset current adjustment (A3R18) will not bring the DVS output voltage to zero in step (p) of paragraph 5-72, A3R19 or A3Q14 is likely to be at fault.

5-51 Gate, Flag, and Storage Strobe Troubleshooting. The simplest method of troubleshooting these circuits is to trace signals with an oscilloscope while providing a gate input from a pulse generator. The pulse generator may be connected between common [3] and either the GATE input jack on the Pocket Programmer or A1TP1. The required pulse amplitude and polarity will depend on the instrument being tested. See the appropriate Option Appendix or the Instrument Modification sheet supplied with the instrument for this information. The minimum pulse width is 5 microseconds; a repetition rate of 10kHz or less is suitable. In the STORAGE mode, check waveforms at test points in the following order: TP2, 3, 4, 6, 7, 40, 31, 41, 42, 16, 43, 8, 9, and 28. In the STORAGE DISABLE mode, check voltages at TP9 and TP28. TP9 should be $\geq$2.4V, TP28 should be $\leq$0.8V referenced to [4] .

NOTE

When tracing signals at each test point, make certain to connect oscilloscope to proper common reference point, either common [3] or common [4] .

CAUTION

[4] common is -26 volts off ground [2] .

5-52 If the signal is lost at TP4, or TP40, one of the delay multivibrators (A1Z3 or A1Z4) or its power supply is at fault. The $+5V_1$, and $+5V_2$ supply voltages for A1Z3 and A1Z4 are derived from the + 12V source supply and components on board A1 (see Figure 7-2, sheet 4). If the gate pulse isolator or flag isolator is at fault, see paragraph 5-53 for isolator troubleshooting instructions.

5-53 PHOTO-ISOLATOR CIRCUIT TROUBLESHOOTING

5-54 Once a trouble has been localized to a particular photo-isolator circuit, following the steps of Table 5-6 or 5-7 will troubleshoot its three main semiconductor components without requiring the removal of any parts from the board. Although some of the photo-isolator circuits in the DVS differ in the means of input drive and some are followed by one or more stages of amplification or inversion, all are generally similar to the circuit, first make sure that all of the two or three dc supplies to the circuit are present. When this has been established, toggle the input bit and observe the collector voltage of the transistor that immediately follows the photo-isolator package (Q2 of Figure 5-8). The

choice of which table should be used depends on the results of that test. If the collector of that transistor remains at a logical high when the input bit is toggled, begin at step (1) of Table 5-6. If that collector remains at a logical low, begin at step (1) of Table 5-7.

NOTE

Marginal photo-isolators in the input circuits on the A1 and A6 boards can cause erroneous output voltage readings and current latch values when operating in the low or high limits of ac input voltage (see paragraph 5-16). This can be detected by programming all photo-isolators to turn-on then turn-on power to the DVS (at low line) and check the output of each storage flip-flop. Thus, the marginal photo-isolation can be detected and replaced.

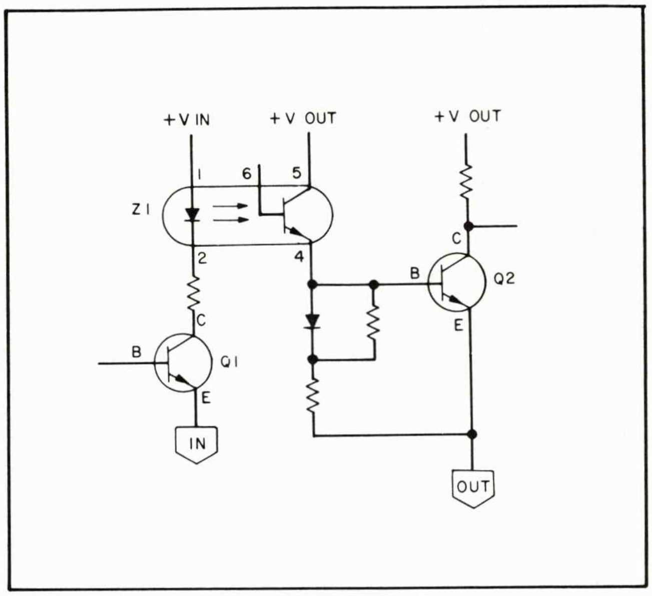


Figure 5-8. Representative Isolator Circuit

Table 5-6. Photo-Isolator Troubleshooting -- Output Remains High

NOTE: Refer to Figure 5-8 for component reference designations used in this table.

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1.	Observe voltage between Q2 collector and OUT common. Shunt Z1 pin 4 to pin 5 momentarily with 1KΩ resistor.	a. Two logic levels present. b. Q2 collector still remain high.	a. Proceed to Step 2. b. Q2 opened. Replace Q2 and retest entire isolator stage. If output now remains low, proceed to Table 5-7.
2.	Observe voltage between Q1 collector and IN common. Toggle input bit.	a. Two logic levels present. b. High logic level only. c. Zero or low logic level only.	a. Z1 failure. b. Proceed to Step 3. c. Proceed to Step 4.
3.	Observe voltage between Q2 collector and OUT common. Short Q1 collector to emitter.	a. Q2 collector goes low. b. Q2 collector remains high.	a. Q1 opened. b. Q1 opened and Z1 failure.
4.	Connect short from Z1 pin 1 to pin 2. Observe voltage between Q1 collector and IN common. Toggle input bit.	a. Two logic levels present. b. Zero or low logic level only.	a. Z1 failure. b. Q1 shorted and Z1 failure.
NOTE: If failure persists, check for bridged or open P.C. conductors.			

Table 5-7. Photo-Isolator Troubleshooting — Output Remains Low

NOTE: Refer to Figure 5-8 for component reference designations used in this table.

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1.	Observe voltage between Q2 collector and OUT common. Short Q2 base to emitter momentarily.	a. Two logic levels present. b. Q2 collector still remains low or zero.	a. Proceed to Step 2. b. Q2 shorted. Replace Q2 and retest entire isolator stage. If output now remains high, proceed to Table 5-6.
2.	Observe voltage between Q2 collector and OUT common. Short Z1 pin 4 to pin 6 momentarily.	a. Two logic levels present. b Q2 collector still remains low or zero. c. High logic level only.	a. Q1 shorted. Replace Q1 and proceed to Step 3. b. Z1 shorted. Replace Z1 and proceed to Step 3. c. Proceed to Table 5-6.
3.	Observe voltage between Q2 collector and OUT common. Toggle input bit.	a. Two logic levels present. b. Q2 collector remains low or zero. c. High logic level only.	a. Repair completed b. Q1 shorted. Replace Q1 and repeat Step 3. c. Proceed to Table 5-6.
NOTE: If failure persists check for bridged or open P.C. conductors.			

5-55 A6 CONTROL BOARD TROUBLESHOOTING

5-56 Since the A6 Board handles many different signals, the troubleshooting for this board has been broken down according to input and output signals. Table 5-8 lists the possible trouble symptoms and directs the reader to the correct paragraph or table for further isolation. Before proceeding to Table 5-8 for the paragraph or table applicable to the trouble present, the following procedure should be used to determine if the trouble lies within the input circuits:

a. Remove the A6 board and install it in the extender board. Install the extender board/A6 combination in the A6 board slot.

b. Connect a voltmeter or logic probe between $\boxed{2}$ common and TP75 of the bit to be tested.

c. Set the STORAGE/DISABLE switch to DISABLE

d. Toggle bit to be tested. If two logic levels can be obtained proceed to Table 5-8. If only one logic level is present, proceed to Paragraphs 5-57, 5-58, and 5-59.

5-57 <u>Current Latch Data Input Circuits Troubleshooting.</u> The following procedure describes the process by which troubles in the current latch data input circuits may be isolated. The process consists of a series of fast checks of the input circuits up to and including the storage flip-flops A6Z2.

5-58 To isolate troubles in the input circuits, proceed as follows:

1. Connect the common lead of an oscilloscope or logic probe to $\boxed{3}$ common.

2. Connect the other lead to TP64 of each of the current latch input bits, and look for the presence of two logic levels as the switch for that bit is toggled. If only one logic level is found at TP64 for any of the bits, check the programming source for defect.

3. Disconnect the leads at TP64 and $\boxed{3}$ and connect them to TP74 of each bit and $\boxed{2}$ Check for the two logic levels as described in Step 2. If only one logic level is present for any of the bits, check the associated pull-up resistor (A6Z1) and photo-isolator circuit (paragraph 5-53).

4. Disconnect the lead of the monitoring device of TP74 and connect it to TP75 of each bit. Check for the presence of two logic levels as described in Step 2. If two logic levels are not present for any of the bits, A6Z1 may be defective. See Paragraph 5-59 and 5-60.

5-59 Storage Gate Pulse Troubleshooting. First determine if the A2 STORAGE DISABLE switch and associated circuits are working by monitoring TP30 (Ref 2) while switching from STORAGE to STORAGE DISABLE. If two logic levels are present these circuits are working on a "static" level, otherwise check the Interconnect Board (A5) and Logic Board (A2) and A6Q4, Q5, Q6 as follows. With A2S1 in the STORAGE position, apply a pulse train to the GATE input terminal J1 pin 32. Check for the presence of a pulse by connecting an oscilloscope or logic probe to 2 common and TP's 28, 69, 70 and 30 in order. Note that TP28 is approximate -26 volts with respect to 2 and 2 is connected to the Low Sense terminal on the rear barrier block. Low Sense is typically connected to chassis ground (⏚). If a point is reached at which the pulse is not present, it may be assumed that the transistor (or related components) just before this point is defective. If the gate pulse is traced through to TP30, it is likely that A6Z2 is defective and must be replaced. Before replacing A6Z2 ensure that +4.99V supply voltage is present at A6Z2, pin 5. If not, check the +4.99V supply components (see Figure 7-2, sheet 4).

5-60 Voltage Range Troubleshooting. To troubleshoot the voltage range circuits, the following procedure is recommended:

1. Connect the common lead of oscilloscope or logic probe to 3 common.

2. Connect the other lead of TP65 and check, by toggling the appropriate switch, for the presence of two logic levels. If only one logic level is present, check the interconnect board for continuity and ensure that the programming device is connected properly.

3. Disconnect the leads of the monitoring device at TP65 and 3 and connect to TP76 and 2 respectfully observing the presence of two logic levels as described in Step 2. If only one logic level is present, check the A6A4 photo-isolator circuit (paragraph 5-53). Also check network A6Z1.

4. Disconnect the lead of the monitoring device from TP76 and connect to TP73 checking for the presence of two logic levels as in Step 2. If only one logic level is present, it is likely that A6Z1 or A6Z2 is defective.

5. Disconnect the lead of the monitoring device from TP73 and connect to TP77 observing the presence of two logic levels as in Step 2. If only one logic level is present, check A6Q25 for an open or short circuit. If two logic levels are present, the trouble lies within the A7 board (A7K1 or A7K2).

5-61 Negative Programmable Output Current Latch Defective. If the unit will current latch for positive output currents, but not for negative output currents; or, if the unit is in current latch for all values of negative output current and works correctly for positive output current latch settings, the cause of trouble must be in a circuit which handles the flow of the negative current latch signal. There are two stages which handle only the negative output current latch signal, A6Z4 and A6CR1.

5-62 Positive Programmable Output Current Latch Defective. If the unit will current latch for negative output currents, but not for positive output currents; or, if the unit is in current latch for all values of positive output current and works correctly for negative output current latch settings, the cause of trouble must be in a circuit which handles the flow of the positive current latch signal only. There are three stages which handle only the positive output current latch signals, A6Z4, A6CR2 and the Negative Reference Inverter (A6Z3, A6Q23, and associated components). Check A6Z4 and A6CR2 first. If these two components are operative, the trouble probably lies in the negative reference inverter. Check A6Z4 and A6CR2 for open or shorted junctions.

5-63 Current Latch Decoder Troubleshooting. To troubleshoot the current latch decoder circuit, the following procedure is recommended:

1. Connect voltmeter positive lead to the NEG REF (TP100) on board A6 and the common lead to TP99. Turn unit on and GATE unit. Set the STORAGE DISABLE switch on A2 to DISABLE.

2. Set the current latch to each value and check that the associated voltage reading is as indicated below:

Current Latch Value (mA)	Voltage Reading (mV) ±10%, ±17mV
20	+25
50	+62.5
70	+87.5
100	+125
200	+250
500	+625

3. If all voltages are incorrect, check current latch decoder stage A6Q1 and the negative reference resistor A6R30. If any voltage reading or combination of voltage readings are incorrect, refer to Table 5-9. Also, check the current latch calibration (paragraph 5-79).

4. Connect voltmeter positive lead to the

POS REF (TP101) on board A6 and the common lead to TP99.

5. Set the current latch to a value of 1000mA and check that voltmeter reads -1.250V ±10%. If reading is incorrect, check the negative reference inverter (A6Q23, Z3) and the positive reference resistor A6R37. Also, check the current latch calibration (paragraph 5-79).

Table 5-8. A6 Troubleshooting Guide

SYMPTOM	A6 TROUBLESHOOTING SECTION
Unit always in current latch	Proceed to Table 5-10
Unable to current latch at turn-on	Proceed to Table 5-11
Unable to current latch at latch setting	Proceed to Table 5-12
Current latch operating properly but latch status is always in the same state (on or off).	Proceed to Table 5-13
Current latch operating properly but overload status is always in the same state (on or off).	Proceed to Table 5-14
Storage gate pulse defective	Proceed to paragraph 5-59
Voltage range defective	Proceed to paragraph 5-60
Positive output current latch defective	Proceed to paragraph 5-62
Negative output current latch defective	Proceed to paragraph 5-61
Flag is not generated for both range switching and overload conditions *	Check the overload/range flag isolator (A6Q31, Q32, Q33, and Z5).
Flag is not generated when range is switched but is generated for an overload condition *	Check 2 millisecond delay circuit (A6CR12, CR13, CR16, Q26, Q27, Q28).
Flag is not generated for an overload condition but is generated when range is switched *	Check overload flag generator (A6CR14, CR15, Q29, Q30).

* Overload Flag is disabled for J20 Option

Table 5-9. Current Latch Decoder Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE
Current latch defective for all values	A6Q1, Q8-Q15, or Z2 defective.
Current latch defective only for the following values: 20, 70, and 200mA	A6Q3 opened, Q13 or Q15 shorted
Current latch defective only for the following values: 50, 100, and 500mA	A6Q3 shorted, Q13 or Q15 opened

Table 5-9. Current Latch Decoder Troubleshooting Guide (Continued)

SYMPTOM	PROBABLE CAUSE
Current latch defective only for the following values: 20, 50, 200, 500mA	A6Q2 opened, Q12 or Q14 shorted
Current latch defective only for the following values: 70 and 100mA	A6Q2 shorted. Q12 or Q14 opened
Current latch works for 20 or 200mA but does not work for both.	A6Q8 defective
Current latch works for 50 or 500mA but does not work for both.	A6Q10 defective
Current latch does not work for 70mA.	A6Q9 defective
Current latch does not work for 100mA.	A6Q8, Q9, Q10 defective

Table 5-10. Unit Always in Current Latch

NOTE: Logic level "1" equals a positive voltage, logic level "0" equals approximately 0V.

STEP	ACTION	RESPONSE	CONCLUSION
1	Connect voltmeter common to $\boxed{2}$. Remove load and ensure that output terminals are not shorted. Turn unit on and Gate unit. Check TP21.	a. Logic level "0" b. Logic level "1"	a. Current latch circuit on A6 board operating properly, check current latch circuit on A7 board (paragraph 5-67). b. Ensure that input plug P1 is connected. Proceed to Step 2.
2	Check TP20	a. Voltage magnitude equals approximately -5V. b. Logic level "1"	a. Buffer stage A6Q21 probably working, go to Step 3. b. Check A6Q21 for open.
3	Check TP14	a. Logic level "1" b. Logic level "0"	a. Reset amplifier working, check A6Q20 for open. If A6Q20 not open, go to Step 4. b. Check Reset Amplifier A6Q24 for short.

Table 5-10. Unit Always in Current Latch (Continued)

STEP	ACTION	RESPONSE	CONCLUSION
4	Check TP98	a. Logic level "0" b. Logic level "1"	a. Relay A4K1 probably working, go to Step 5. b. Relay A4K1 defective causing false setting of latching flip-flop A6Q19, Q20.
5	Check TP19	a. Logic level "1" b. Logic level "0"	a. Latching flip-flop probably working, go to Step 6. b. Check A6Q19 for short.
6	Check TP18	a. Logic level "1" b. Logic level "0"	a. Level detector A6Q17 and A6Q18 probably good, go to Step 7. b. Check A6Q17 for short and A6Q18 for open.
7	Check TP17	a. Voltage magnitude $<+0.5V$ b. Logic level "1"	a. Variable delay A6Q16 probably operating, go to Step 8. b. Check A6Q16 for open.
8	Connect voltmeter common to TP99 and check TP15	a. Voltage magnitude is less than 20mV. b. Voltage magnitude is more than 20mV	a. Current sampling circuit operating properly, go to Step 9. b. Check current sampling resistor and interconnect wires.
9	Connect voltmeter common to 2 Check TP35	a. Logic level "1" b. Voltage magnitude equals approximately -13V.	a. Negative current comparator is operating properly, go to Step 10. b. Check current latch decoder (see para. 5-63). If current latch decoder circuits are operating properly check the negative current comparator circuit (A6Z4, R39, R33, R31).
10	Check TP36	a. Logic level "1"	a. Positive current comparator is operating properly, check OR gate (A6CR1, CR2) for shorts.

Table 5-10. Unit Always in Current Latch (Continued)

STEP	ACTION	RESPONSE	CONCLUSION
10	Check TP36 (Continued)	b. Voltage magnitude equals approximately -13V.	b. Check current latch decoder (see para. 5-63). If current latch decoder circuits are operating properly, check the positive current comparator (A6Z4, R32, R34, R43) and the negative reference inverter (A6Q3, Z3).

Table 5-11. Unable to Current Latch at Turn-On

NOTE: Positive voltage equals logic level "1"; logic level "0" equals approximately 0V.

STEP	ACTION	RESPONSE	CONCLUSION
1	Turn unit off. Measure Impedance between 2 and TP98.	a. Impedance ≥ 5KΩ b. Impedance < 5KΩ	a. Relay A4K1 probably working, go to Step 2. b. Relay A4K1 defective causing false resetting of latching flip-flop.
2	Connect voltmeter common to 2 Turn unit on (Do <u>not</u> GATE). Check TP21	a. Logic level "0" b. Logic level "1"	a. No latch go to Step 3. b. Latch circuit on A6 board is operating, check latch circuit on A7 board (paragraph 5-67).
3	Check TP20	a. Logic level "1" b. Voltage magnitude equals approximately -5V.	a. Buffer stage A6Q21 probably working, go to Step 4. b. Buffer stage A6Q21 not working, check A6Q21 for short.
4	Check TP14	a. Logic level "0" b. Logic level "1"	a. A6Q20 probably working. Reset amplifier may be defective. Check A6 Q24 for short and A6Q22 for open. If reset amplifier is working properly, go to Step 5. b. Check A6Q20 for short.
5	With an oscilloscope, observe operation of A4K1 (TP98) and turn-on of power (TP88). Both referenced to 2	a. TP98 goes low ≈200ms after power on. b. TP98 goes low <200ms after power on.	a. Delay for A4K1 working; check complete. b. Check -12V delayed circuit especially A4C10, CR22 for shorts (see Figure 7-2, sheet 4).

Table 5-12. Unable to Current Latch at Latch Settings

NOTE: Logic level "1" equals a positive voltage, logic level "0" equals approximately 0V.

STEP	ACTION	RESPONSE	CONCLUSION
1	Turn unit off. Measure impedance from TP18 to [2] (connect positive meter lead to TP18)	a. Impedance >1KΩ b. Impedance < 1KΩ	a. Go to Step 2 b. C_T terminals on barrier strip are shorted or electrolytic capacitor used is connected with reverse polarity.
2	Short the output terminals and turn unit on. Program the current latch and voltage magnitude values in question then Gate unit.	a. Output current < 20mA b. Output current ≥100% of rated output	a. Check completed. Problem caused by improper setting of current latch value or current latch not calibrated (see paragraph 5-79). b. Latch circuits not working, go to Step 3.
3	Connect meter common to [2] and check TP21	a. Logic level "1" b. Logic level "0"	a. Current latch circuits on A6 board operating properly, check current latch circuit on A7 board (see paragraph 5-67). b. A6 latch circuits not working, go to Step 4.
4	Check TP20	a. Logic level "1" b. Voltage magnitude equals approximately -5V	a. Buffer stage A6Q21 probably working, go to Step 5. b. Check Buffer Stage A6Q21 for short.
5	Check TP19	a. Logic line "0" b. Logic level "1"	a. Latching flip-flop probably working, go to Step 6. b. Check latching flip-flop transistor A6Q20 for short and A6C5 for open.
6	Check TP18	a. Logic level "0" b. Logic level "1"	a. Level detector (A6Q17, Q18) probably working, go to Step 7. b. Level detector not working. Check A6Q17 for open and A6Q18 for short.
7	Check TP17	a. Logic level "1" b. Voltage magnitude < +0.5V	a. Variable delay A6Q16 probably working, go to Step 8. b. Check A6Q16 for short

Table 5-12. Unable to Current Latch at Latch Settings (Continued)

NOTE: Logic level "1" equals a positive voltage, logic level "0" equals approximately 0V.

STEP	ACTION	RESPONSE	CONCLUSION
8	Check TP35 and TP36	a. Both logic level "1" b. Either equals approximately -13V. c. Both equal approximately -13V.	a. Go to Step 9 b. CR1, CR2, or VR2 open c. CR1 and CR2 open, go to Step 9.
9	Connect voltmeter common to TP99 and check TP15	a. Voltage magnitude equals 0.625V ±10% b. Voltage magnitude does not equal 0.625V ± 10%	a. Current sampling circuit operating properly, go to Step 10. b. Check current sampling resistor and interconnections.
10	Set current latch to 500mA. With voltmeter common connected to TP99, check the NEG REF (TP100).	a. Voltage equals +0.625V ±10% b. Voltage does not equal +0.625V ±10%	a. Current latch decoder operating properly. Check the negative current comparator (A6Z4, R31, R33, R39) Proceed to Step 11. b. Check current latch decoder (see paragraph 5-63).
11	Check POS REF (TP101) with meter common connected to TP99	a. Voltage equals -0.625V ±10% b. Voltage does not equal -0.625V ±10%	a. Negative reference inverter operating properly. Check positive current comparator (A6Z4, R32, R34, and R43). b. Check negative reference inverter (A6Z3, Q23).

Table 5-13. Latch Status Troubleshooting

STEP	ACTION	RESPONSE	CONCLUSION
1	Check the operation of A6A5Q4 by first shorting A6A5Q3 emitter to base and then emitter to collector. Monitor the output with a voltmeter *connected between TP22 and 3 common.	a. Only one logic level present b. Two logic levels present	a. A6A5Q4 defective or A6A5Q3 shorted b. Remove short and proceed to Step 2.

*If there is no pull-up resistor (A6A5R8), use an ohmmeter.

Table 5-13. Latch Status Troubleshooting (Continued)

STEP	ACTION	RESPONSE	CONCLUSION
2	Check the operation of A6A5Q3 by shorting A6A5Q2 first emitter to collector and then emitter to base. Monitor the output after each operation as described in Step 1.	a. One logic level present b. Two logic levels present	a. A6A5Q3 defective or A6A5Q2 shorted b. Remove short and check the operation of the latch status photo isolator circuit (see paragraph 5-53).

Table 5-14. Overload Status Troubleshooting

STEP	ACTION	RESPONSE	CONCLUSION
1	If A6A6Q4 is in the circuit (see modifications sheet) test its operation by first shorting A6A6Q3 emitter to base. Monitor the output with a voltmeter * connected between TP25 and 3 common after each operation.	a. Only one logic level present b. Two logic levels present	a. A6A6Q4 defective or A6A6Q3 shorted. b. Remove short and proceed to Step 2.
2	Check the operation of A6A6Q3 by shorting A6A6Q2 first emitter to collector and then emitter to base. Monitor the output after each operation as described in Step 1.	a. One logic level present b. Two logic levels present	a. A6A6Q3 defective or A6A6Q2 shorted. b. Remove short and check the operation of the overload status photo-isolator circuit (see paragraph 5-53).

* If there is no pull-up resistor (A6A6R8), use an ohmmeter.

5-64 A7 POWER AMPLIFIER BOARD TROUBLESHOOTING

5-65 Before attempting to troubleshoot the power amplifier, it is important to classify the kind of trouble present according to the trouble symptoms. Generally, troubles in the A7 board generate two broad categories of symptoms: current latch problems and output voltage problems. For example, if output voltages can be programmed with no load but no current can be drawn when a load is added, the problem is most likely a current latch type. However, if output voltages cannot be programmed without a load, the problem is probably an output voltage type.

5-66 The A7 troubleshooting procedures thus, are divided into two categories according to fault symptoms. The symptoms listed in Table 5-3 can be related to these two categories.

5-67 Current Latch Troubleshooting. Current latch problems on the A7 board can be caused by the current latch circuits themselves (the current latch isolators and switch circuits) or subsequent circuits including the power amplifier, power output, or positive and negative bias circuits. Figure 5-9A presents a procedure for dividing the fault path between either the A7 current latch circuits or the power circuits. If this procedure indicates the fault is in the current latch circuits, Figure

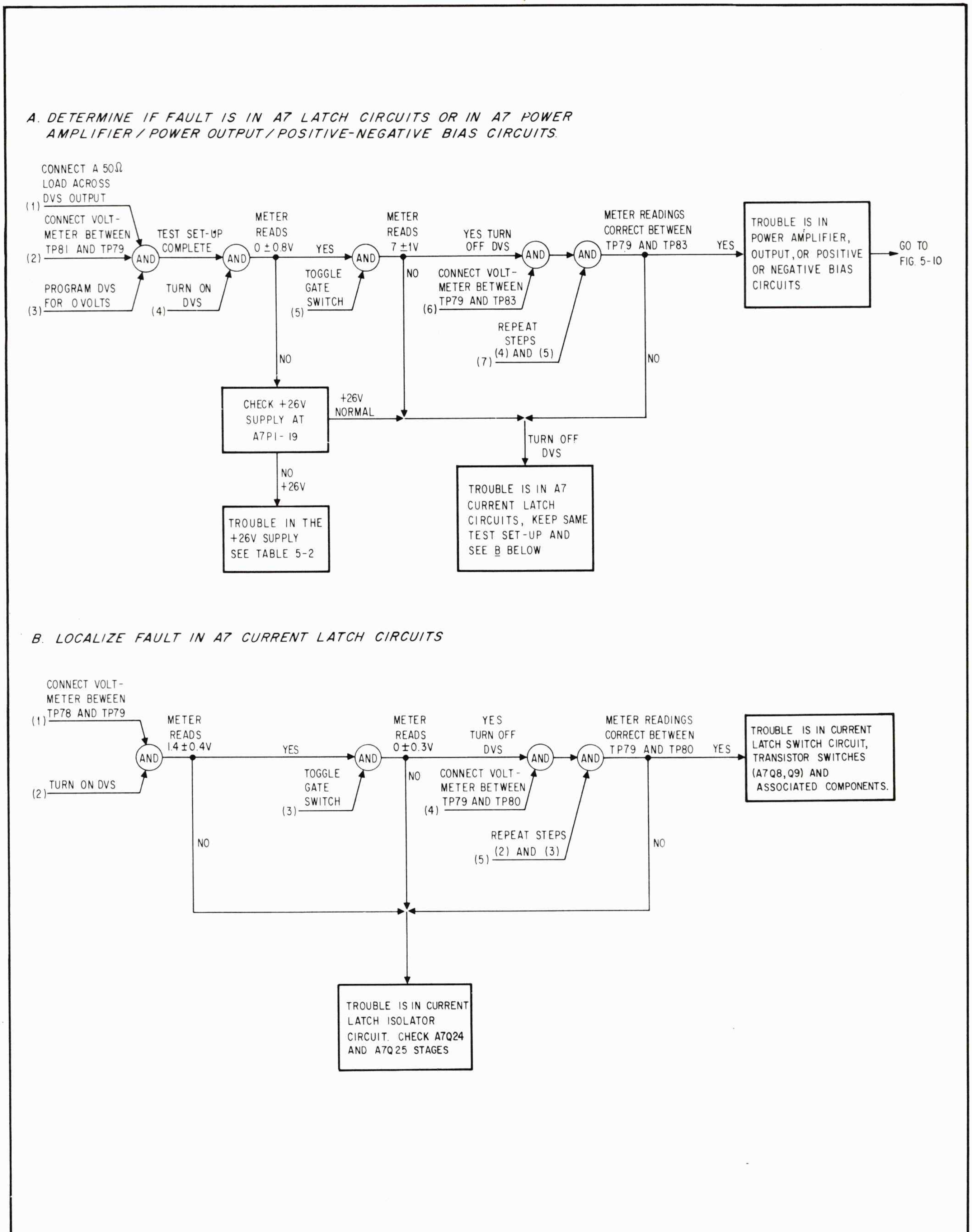
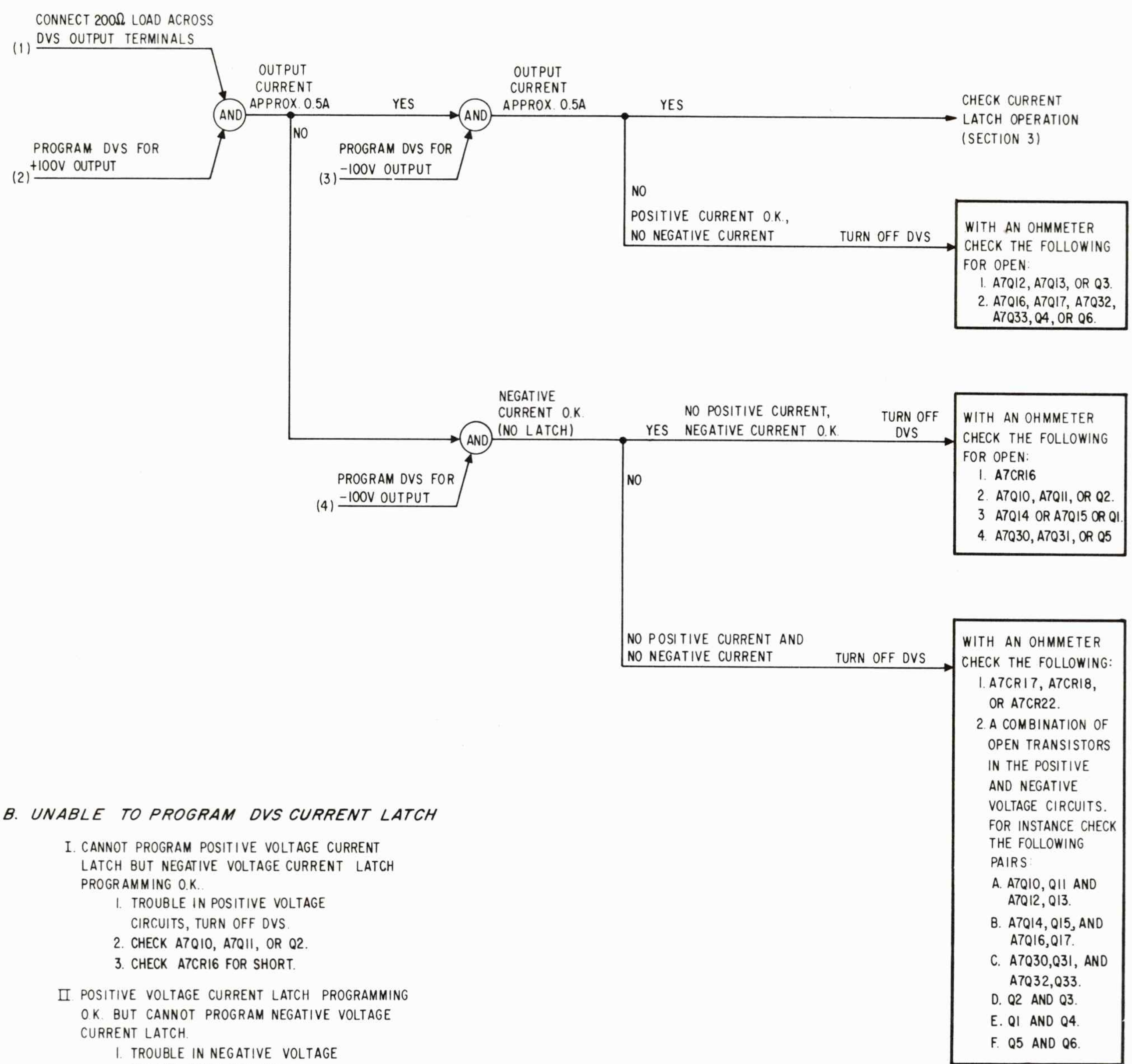


Figure 5-9. A7 Power Amplifier Current Latch Troubleshooting

A. UNABLE TO GET DVS OUT OF CURRENT LATCH



B. UNABLE TO PROGRAM DVS CURRENT LATCH

I. CANNOT PROGRAM POSITIVE VOLTAGE CURRENT LATCH BUT NEGATIVE VOLTAGE CURRENT LATCH PROGRAMMING O.K.
   1. TROUBLE IN POSITIVE VOLTAGE CIRCUITS, TURN OFF DVS.
   2. CHECK A7Q10, A7Q11, OR Q2.
   3. CHECK A7CR16 FOR SHORT.

II. POSITIVE VOLTAGE CURRENT LATCH PROGRAMMING O.K. BUT CANNOT PROGRAM NEGATIVE VOLTAGE CURRENT LATCH.
   1. TROUBLE IN NEGATIVE VOLTAGE CIRCUIT, TURN OFF DVS.
   2. CHECK A7Q12, A7Q13, OR Q3.
   3. CHECK A7CR18, A7CR21, A7CR22.

Figure 5-10. Localize Current Latch Trouble

5-9B provides a procedure for localizing the fault to either the current latch isolator or the current latch switch stages. If the procedure of Figure 5-9A indicates that the fault is in the power circuits, the procedure given in Figure 5-10 can be used to localize the fault to the defective stage within the power circuits.

5-68 Output Voltage Troubleshooting. The power amplifier contains four functional circuits (current latch, gross current limit, feedback differential amplifier, and power amplifier) any one of which can cause a failure in output voltage (the failure being that output voltage is locked up or down-full positive or full negative-or zero). The first step in troubleshooting then, is to isolate the trouble to one of the four circuit groups. Once this is accomplished, the defective part of the faulty circuit can be located by more detailed troubleshooting. The following procedures will isolate trouble to one of the four circuit groups by systematically eliminating each circuit from the loop, one at a time, and noting if the output voltage returns to normal after each circuit isolation.

1. Disconnect the load and insure that the output terminals are not short circuited.
2. Program for 0V output.
3. Isolate the gross current limiters from the loop by opening the connection from A7CR23 and CR36 to the base of A7Q6.
4. Program the output voltage 100 volts above and below 0 volts, in 5 volt steps.
5. If the original trouble still exists, reconnect the gross current limiters and proceed to Step (6). If the original trouble is eliminated, turn the DVS off and troubleshoot the gross current limiters (Table 5-15).
6. Isolate the current latch circuits by opening the connection from diodes A7CR15 and CR20 to the power amplifier.
7. Repeat Step (4).
8. If the original trouble still exists, reconnect the current latch circuits and proceed to Step (9). If the original trouble is eliminated, turn the DVS off and troubleshoot the current latch circuits (Paragraph 5-67).
9. Program the DVS for 0V output.
10. Isolate the feedback differential amplifier from the output power stages by strapping A7Q6 base to emitter.
11. Simulate the output of the feedback differential amplifier by connecting a 100KΩ potentiometer (set to mid position) between the collector of A7Q6 and 1.
12. Slowly rotate the potentiometer shaft cw and ccw while observing the output voltage.
13. If the output voltage tracks the potentiometer settings (indicating that the output power stages are normal) and the original trouble was a locked-down condition, proceed to Table 5-16.
14. If the voltage tracks the potentiometer settings and the original trouble was a locked-up condition, proceed to Table 5-17.
15. If the output voltage does not respond to the potentiometer settings, check the power amplifier (A7Q7 and Q10 through Q13) the bias networks (A7Q14 through Q17 and Q30 through Q33) and the output drivers (Q1 through Q6).
16. Remove the strap and potentiometer from A7Q6.

Table 5-15. Gross Current Limiters Troubleshooting

STEP	ACTION	RESPONSE	CONCLUSION
1	With the load removed from the DVS, the output programmed for 0V, and the gross current limiters disconnected from the base of A7Q6, monitor the voltage at the anode of A7CR36.	-6 ±1Vdc	If the monitored voltage is positive, the negative gross current limiter is locked in the limiting state. Check A7Q18-20
2	Monitor the voltage at the cathode of A7CR23.	-0 ±1Vdc	If the monitored voltage is excessively negative, the positive gross current limiter is locked in the limiting state. Check A7Q21-23.
3	Again monitor the voltage at the anode A7CR36, but this time connect a 100Ω, 50 watt load and increase output to a negative level sufficient to draw -550mA.	Monitored voltage switches to + 4.5Vdc at + 550 ±50mA	If the voltage does not switch, the negative gross current limiter is not limiting. Check A7Q18-20.

Table 5-15. Gross Current Limiters Troubleshooting (Continued)

STEP	ACTION	RESPONSE	CONCLUSION
4	Repeat Step 3, except monitor the voltage at the cathode of CR23 and increase positive output voltage to draw +550mA.	Monitored voltage switches to -20V (approximately) at -550 ±50mA	If the voltage does not switch, the positive gross current limiter is not limiting. Check A7Q21-23

Table 5-16. Feedback Differential Amplifier Troubleshooting, Unit Locked Down (Full Negative)

STEP	ACTION	RESPONSE	CONCLUSION
1	Short A7Q5 emitter to collector	a. Output voltage remains low b. Output voltage increases	a. A7Q6 shorted. b. Remove short and proceed to Step 2.
2	Short A7Q4 emitter to collector	a. Output voltage remains low b. Output voltage increases	a. A7Q5 opened. b. Remove short and proceed to Step 3.
3	Short A7Q3 base to emitter	a. Output voltage remains low b. Output voltage increases	a. A7Q4 opened, A7Q3 shorted. b. Remove short and proceed to Step 4.
4.	Short A7Q1B emitter to collector	a. Output voltage remains low b. Output voltage increases	a. A7Q2 defective b. Remove short. Check A7Q1A for short and Q1B for open.

Table 5-17. Feedback Differential Amplifier Troubleshooting, Unit Locked Up (Full Positive)

STEP	ACTION	RESPONSE	CONCLUSION
1	Short A7Q5 emitter to base.	a. Output voltage remains high. b. Output voltage decreases.	a. A7Q6 opened, A7Q5 shorted. b. Remove Q5 short and proceed to Step 2.
2	Short A7Q2B emitter to collector and A7Q2A emitter to base.	a. Output voltage remains high. b. Output voltage decreases.	a. A7Q4 shorted, A7Q3 opened, or A7Q2A shorted. b. Remove Q2 shorts and proceed to Step 3.
3	Short A7Q1A emitter to collector, A7Q1B emitter to base.	a. Output voltage remains high. b. Output voltage decreases.	a. A7Q2B opened or A7Q1B shorted. b. Remove shorts. Check A7Q1 for defects.

5-69 ADJUSTMENT AND CALIBRATION

5-70 Adjustment and calibration may be required after performance testing, troubleshooting or repair and replacement. Perform only those adjustments that affect the operation of the faulty circuit and no others. All the controls referred to in these adjustments are shown on the component location diagrams in Section VII.

5-71 OUTPUT VOLTAGE ADJUSTMENT

5-72 Before proceeding to the following adjustment procedures, make the following preparations:

1. Strap the following terminals on the rear terminal strip of the DVS:
   a. LO to LO S to GND
   b. HI to HI S
2. Connect the Pocket Programmer to the data input connector and set its switches as follows:
   a. Set the INPUT LEVEL REF switch to DATA COM.
   b. Set the MP/DCPS switch to DCPS.
   c. Set the SOURCE SELECT switch to EXT.
   d. Set the RANGE switch to X1.
   e. Set the data and sign bit switches for a negative zero output. (Refer to the appropriate Option Appendix or Instrument Modification sheet for the correct data and sign bit coding. Data bit switches will be either all up or all down.

f. Set the I LIMIT switches for a 500mA limit.

3. Set the switch on the A2 board to the STORAGE DISABLE position.

4. Connect a digital voltmeter across the HI S and LO S output terminals.

5. Turn on DVS and momentarily depress GATE switch on Pocket Programmer to deactivate the current latch circuit.

6. Test the voltage processing circuits by individually turning on each bit and observing the relative change in output voltage associated with each bit value. If any voltage bits are not functioning, calibration can not be accomplished (refer to troubleshooting procedures, paragraph 5-37). If all voltage bits are functioning, proceed as follows:

NEGATIVE ZERO CALIBRATION

a. Turn DVS off. Remove bottom cover in order to gain access to potentiometer A7R9. Note that if the DVS is installed in a system, both the A3 and A7 boards must be placed in extender boards to perform this calibration.

b. Set all of the potentiometers on the A3 board (A3R18, A3R36, A3R52 through A3R59, and A3R100) to midrange.

c. Set the data and sign bit switches on the Programmer for an output of 0 volts. Set OUTPUT SIGN switch for negative voltages.

d. Turn on DVS and momentarily depress GATE switch on the programmer. Allow a 30-minute DVS warm-up period.

CAUTION

High voltages are present on the amplifier board A7.

e. Set the RANGE switch on the Programmer to the X10 position and measure the output voltage.

f. Set the RANGE switch to the X1 position and adjust A7R9 until a reading 1/10 the reading in step (e) is obtained.

g. Repeat steps (e) and (f) until no further adjustments are needed.

h. Set the RANGE switch to the X10 position and adjust A3R100 for a reading of 0 ±1mV.

i. Repeat steps (e) through (h) until no further adjustments are needed.

POSITIVE 16-VOLT REFERENCE ADJUST

j. On the Programmer, set the RANGE switch to X1 and the OUTPUT SIGN switch for negative polarity.

k. Connect a digital voltmeter across capacitor A3C30.

l. Adjust A3R36 for a reading of 16.012 ±.003V.

INDIVIDUAL BIT CALIBRATION

m. The individual bits are adjusted in two groups (A8, A4, A2, A1, and B8, B4, B2, B1) according to the table below. The adjustment of all bits in the first group should be completed before proceeding to the second group. If any potentiometer in a group is adjusted to its end stop, continue adjusting the remaining potentiometers in the group and then back off 10% on the potentiometer that reached its end stop. Reprogram the bit associated with the potentiometer that was adjusted to its end stop and then adjust A3R36 for the correct output voltage level: If A3R36 must be adjusted, the entire bit calibration procedure must be repeated.

Voltage Bit	Meter Reading	Potentiometer
A8	-8V ±100μV	A3R52
A4	-4V ±100μV	A3R53
A2	-2V ±100μV	A3R54
A1	-1V ±100μV	A3R55
B8	-0.8V ±30μV	A3R56
B4	-0.4V ±30μV	A3R57
B2	-0.2V ±30μV	A3R58
B1	-0.1V ±30μV	A3R59

n. Check each of the remaining bits (C8, C4, C2, C1, D8, D4, D2, and D1) to insure that they are within ±200μV. If not, check the associated switching transistors and ladder network on the A3 board (see Figure 7-2, sheet 1).

POSITIVE ZERO VOLTAGE AND X10 FEEDBACK RESISTOR ADJUSTMENT CALIBRATION

o. Set the data and sign bits on the Programmer for an output of 0 volts.

p. Adjust A3R18 for 0V ±100μV.

q. Turn on the A4 bit and observe the voltage reading.

r. Set the Programmer RANGE switch to X10 and adjust A7R85 for 10 times and the reading in Step (q) ±1mV.

s. Repeat Steps (p) through (r) until no further adjustments are necessary.

t. Turn off DVS and replace bottom cover or remove extender boards and replace boards as applicable.

5-73 METER ZERO

5-74 To zero-set either the voltmeter or ammeter, proceed as follows:

a. Turn the instrument off. Wait one minute for power supply capacitors to discharge completely.

b. Insert sharp object (pen point or awl) into the small indentation near the top of the round black plastic disc located directly below the meter face.

c. Rotate the disc until meter reads exactly zero.

5-75 VOLTMETER ADJUSTMENT

5-76 To adjust the calibration of the DVS voltmeter, proceed as follows:

a. On the Pocket Programmer, set the data bits, OUTPUT SIGN, and RANGE switches for a voltage output of +20V.

b. Turn on DVS and press GATE switch on Programmer.

c. Set the DVS front panel VOLTAGE control to the 20V position and adjust A4R14 until meter reads +20V.

d. Set the data bit, OUTPUT SIGN, and RANGE switches for an output voltage of -20V. The voltmeter should read -20V.

e. If it does not, halve the error and adjust A4R14 accordingly.

5-77 AMMETER ADJUSTMENT

5-78 To adjust the calibration of the DVS Ammeter proceed as follows:

a. Connect a 200 ohm, 50 watt, 1% resistor across the HI and LO output terminals.

b. On the Programmer set the data bit, OUTPUT SIGN, and RANGE switches for an output voltage of +99.99V.

c. Turn on DVS and press GATE switch on Programmer.

d. Set the DVS front panel CURRENT switch to 0.6A and adjust A4R24 until ammeter reads +0.5A.

e. Set the data bit, OUTPUT SIGN, and RANGE switches for an output voltage of -99.99V. The meter should read -0.5A.

f. If it does not, halve the error and adjust A4R24 accordingly.

5-79 CURRENT LATCH ADJUSTMENT

5-80 To calibrate the accuracy of the current latch circuit, proceed as follows:

a. Remove the A6 control board, and using the extender board, place A6 in the extended position. Short the C_T terminals (rear barrier strip).

b. Connect a voltmeter across A6A6Q3 (Figure 7-2, Sheet 2). Connect meter positive to base and common to emitter of A6A6Q3. When the overload point is reached, the voltmeter will read approximately 0.7 volts.

c. Attach a 200 ohm, 50 watt, 1% load resistor across the HI and LO output terminals.

d. Set the switches on the Pocket Programmer for an output voltage of -4.00V and a current latch of 20mA.

e. Adjust potentiometers A6R19, R20, R21, and R108 fully clockwise.

f. Turn on DVS and press GATE switch on Pocket Programmer. Allow a 30-minute DVS warm-up period.

g. Adjust A6R19 ccw until the voltmeter indicates approximately 0.7V.

h. Program the voltage to -10.00V and the current latch to 50mA.

i. Adjust A6R21 ccw until the voltmeter indicates approximately 0.7V.

j. Program the voltage to -14.00V and the current latch to 70mA.

k. Adjust A6R20 until the voltmeter indicates approximately 0.7V.

l. Program the voltage to +4.00V and the current latch to 20mA.

m. Adjust A6R108 until voltmeter indicates approximately 0.7V.

117Ω load (4 wire)

W/MISLABELED DG CONT =
20m = 111 -4V
50 = 101 -10V
70 = 110 -14V

24 22 23

500 = 001

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor	VR	= zener diode
R	= resistor	X	= socket
S	= switch	Z	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
cd	= card	NP	= nickel-plated
coef	= coefficient	Ω	= ohm
comp	= composition	obd	= order by description
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
DPST	= double pole, single throw	p-p	= peak-to-peak
elect	= electrolytic	ppm	= parts per million
encap	= encapsulated	pvr	= peak reverse voltage
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry	SPST	= single pole, single throw
Hz	= Hertz	SS	= small signal
IC	= integrated circuit	T	= slow-blow
ID	= inside diameter	tan.	= tantulum
incnd	= incandescent	Ti	= titanium
k	= kilo = 10^3	V	= volt
m	= milli = 10^{-3}	var	= variable
M	= mega = 10^6	ww	= wirewound
μ	= micro = 10^{-6}	W	= Watt
met.	= metal		

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Div.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co. Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co. Inc.	Indianapolis, Ind.
06751	Semcor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, Ind.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Camera and Instrument Corp. Semiconductor Div.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc. Sylvania Electronic Systems Western Div.	Mountain View, Calif.
07716	IRC Div. of TRW Inc. Burlington Plant	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div. Semiconductor Operation	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Miniature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc. Boone Plant	Boone, N.C.
11711	General Instrument Corp Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co. Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co. Loveland Div.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N.J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N.J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N.H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G.E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co. Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I.T.T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp.	Newark, N.J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N.J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N.Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N.J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J.W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semi-conductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N.J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L.I.C., N.Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A1	Input Board		Refer to proper Option Appendix			
A1A1	Isolator circuit					
CR1,2	Diode, Si 200mA 75V	2		28480	1901-0050	2
Q1,2	SS NPN Si	2		28480	1854-0071	2
R1,2,3			Refer to proper Option Appendix			
R4	fxd, comp 750Ω ±5%, 1/2W	1	EB-7515	01121	0686-7515	1
R5	fxd, comp 82Ω ±5%, 1/4W	1	CB-8205	01121	0683-8205	1
R6	fxd, comp 750Ω ±5%, 1/4W	1	CB-7515	01121	0683-7515	1
Z1	Photo-Isolator	1		28480	1990-0407	1
A1A2 through A1A17	Same as A1A1	16				
A1C1-3	fxd, ceramic .47μF 25Vdc	3		28480	0160-0174	1
C4	fxd, ceramic .1μF 50Vdc	2		28480	0150-0121	1
C5	fxd, mica 390pF 300Vdc	1	RDM15F39153C	72136	0140-0200	1
C6	fxd, mylar .01μF 200Vdc	1	292P10352-PTS	56289	0160-0207	1
C7	fxd, ceramic .1μF 50Vdc			28480	0150-0121	
CR1-4	Diode, Si 200mA 75V	4		28480	1901-0050	4
Q1			Refer to Instrument Modification Sheet			
Q2-Q5	SS NPN Si	4		28480	1854-0071	4
Q6			Refer to proper Option Appendix			
Q7			Refer to Instrument Modification Sheet			
R1,2,3			Refer to proper Option Appendix			
R4			Refer to Instrument Modification Sheet			
R5	fxd, comp 1KΩ ±5%, 1/4W	3	CB-1025	01121	0683-1025	1
R6	fxd, ww 100Ω ±5%, 3W	2	242E	56289	0813-0050	1
R7	fxd, met film 11KΩ ±2%, 1/8W	1	MF4C TD	30983	0757-0949	1
R8	fxd, met film 7.5KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0757-0440	1
R9	fxd, comp 1KΩ ±5%, 1/4W		CB-1025	01121	0683-1025	
R10	fxd, ww 100Ω ±5%, 3W		242E	56289	0813-0050	
R11	fxd, comp 3KΩ ±5%, 1/4W	1	CB-3025	01121	0683-3025	1
R12	fxd, comp 910Ω ±5%, 1/2W	1	EB-9115	01121	0686-9115	1
R13	fxd, comp 750Ω ±5%, 1/2W	1	EB-7515	01121	0686-7515	1
R14	fxd, comp 750Ω ±5%, 1/4W	2	CB-7515	01121	0683-7515	1
R15			Refer to proper Option Appendix			
R16	fxd, comp 82Ω ±5%, 1/4W	2	CB-8205	01121	0683-8205	1
R17,18,19			Refer to proper Option Appendix			
R20	fxd, comp 1KΩ ±5%, 1/4W		CB-1025	01121	0683-1025	
R21	fxd, comp 750Ω ±5%, 1/4W		CB-7515	01121	0683-7515	
R22	fxd, comp 82Ω ±5%, 1/4W		CB-8205	01121	0683-8205	
R23	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
VR1	Diode, zener 4.22V 400mW	2		28480	1902-3070	2
VR2,3	Diode, zener 4.99V	2	SZ11213-54	04713	1902-0533	2
VR4	Diode, zener 4.22V 400mW			28480	1902-3070	
VR5			Refer to proper Option Appendix			
Z1,2	Photo-Isolator	2		28480	1990-0407	2
Z3,4	Monostable Multivibrator, IC	2	SN13617	01295	1820-0261	2
A2	Logic Board		Refer to proper Option Appendix			
A2A1C1	fxd, ceramic .47μF 25Vdc	1		28480	0160-0174	1
A1Z1			Refer to proper Option Appendix			
A1Z2-6	4 2-Input NAND Gate, IC	5		28480	1820-0054	5
A1Z7			Refer to Proper Appendix			

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A2A2 through A2A4	Same as A2A1					
A2 C1	fxd, ceramic .47μF 25Vdc	2		28480	0160-0174	1
C2	fxd, mica 150pF 300Vdc	1	RDM15F151J3C	72136	0140-0196	1
C4	fxd, ceramic .47μF 25Vdc			28480	0160-0174	
C5	fxd, tant. 4.7μF 6Vdc	1	150D475X5006A2-DYS	56289	0180-1954	1
DS1	Lamp, 6Vdc incandescent	1	2305RA	11115	2140-0324	1
R1	fxd, film 30.1KΩ ±1%, 1/8W	1		28480	0757-0453	1
R2	fxd, comp 5.1KΩ ±5%, 1/4W	1	CB-5125	01121	0683-5125	1
R3	fxd, comp 1KΩ ±5%, 1/4W	3	CB-1025	01121	0683-1025	1
R4	fxd, comp 200Ω ±5%, 1/4W	1	CB-2015	01121	0683-2015	1
R5	fxd, comp 1KΩ ±5%, 1/4W		CB-1025	01121	0683-1025	
R6	fxd, comp 510Ω ±5%, 1/4W	2	CB-5115	01121	0683-5115	1
R7	fxd, comp 3KΩ ±5%, 1/4W	1	CB-3025	01121	0683-3025	1
R8	fxd, comp 430Ω ±5%, 1/4W	1	CB-4315	01121	0683-4315	1
R9	fxd, comp 2KΩ ±5%, 1/4W	2	CB-2025	01121	0683-2025	1
R10	fxd, comp 4.7KΩ ±5%, 1/4W	1	CB-4725	01121	0683-4725	1
R11	fxd, comp 510Ω ±5%, 1/4W		CB-5115	01121	0683-5115	
R13	fxd, comp 1KΩ ±5%, 1/4W		CB-1025	01121	0683-1025	
R14	fxd, comp 2KΩ ±5%, 1/4W		CB-2025	01121	0683-2025	
Q1-4	SS NPN Si	4		28480	1854-0071	4
S1	Switch, slide DPDT	1		28480	3101-0932	1
Z1-3	Quad, 2-Input NAND Gate, IC	3		28480	1820-0054	3
Z4	Monostable Multivibrator, IC	1	SN13617	01295	1820-0261	1
Z5,6	Hybrid Resistive Network, IC	2		28480	1810-0041	1
A3	D to A Converter Plug-In Board	1		28480	5060-6191	
A3A1C1	fxd, ceramic .001μF 500Vdc	1		28480	0160-3398	1
C2	fxd, ceramic .005μF 100V	1		28480	0160-2639	1
CR1-3	Diode, Si 200mA 75V	3		28480	1901-0050	3
Q1	SS NPN Si	1		28480	1854-0087	1
Q2	SS PNP Si	1		28480	1853-0078	1
Q3	SS NPN Si	1		28480	1854-0317	1
R1	fxd, comp 3.3KΩ ±5%, 1/2W	1	EB-3325	01121	0686-3325	1
R2	fxd, comp 12KΩ ±5%, 1/2W	1	EB-1235	01121	0686-1235	1
R3	fxd, comp 2.2KΩ ±5%, 1/2W	1	EB-2225	01121	0686-2225	1
R4,5	fxd, comp 10KΩ ±5%, 1/2W	2	EB-1035	01121	0686-1035	1
A3A2 through A3A15	Same as A3A1	13				
A3A16C1	fxd, ceramic .001μF 500Vdc	1		28480	0160-3398	1
C2	fxd, ceramic .005μF 100V	1		28480	0160-2639	1
CR1-3	Diode, Si 200mA 75V	3		28480	1901-0050	3
Q1	SS NPN Si	1		28480	1854-0087	1
Q2	SS PNP Si	1		28480	1853-0078	1
Q3	SS NPN Si	1		28480	1854-0317	1
A3A16R1	fxd, comp 3.3KΩ ±5%, 1/2W	1	EB-3325	01121	0686-3325	1
R2	fxd, comp 10KΩ ±5%, 1/2W	3	EB-1035	01121	0686-1035	1
R3	fxd, comp 2.2KΩ ±5%, 1/2W	1	EB-2225	01121	0686-2225	1
R4,5	fxd, comp 10KΩ ±5%, 1/2W	2	EB-1035	01121	0686-1035	1
R6	fxd, comp 33KΩ ±5%, 1/2W	1	EB-3335	01121	0686-3335	1
A3AR-Z1	Ref. Amp. 6.8V ±5% TC ±.0005%	1		28480	5080-7137	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A3AR-R1	fxd, ww - Part of 5080-7137	1				
AR-R2	fxd, film - Part of 5080-7137	1				
AR-R3	fxd, film - Part of 5080-7137	1				
AR-R4	fxd, film - Part of 5080-7137	1				
A3C5	fxd, mica 330pF 500Vdc	1	RCM15331J	00853	0140-0168	1
C11	fxd, ceramic .001μF 500Vdc	1		28480	0160-3398	1
C12	fxd, mylar .01μF 200V	1	192P10392	56289	0160-0161	1
C13,30	fxd, elect. 22μF 35V	2	150D226X0035R2	56289	0180-0160	1
C40,41	fxd, elect. 1μF 35Vdc	2	150D105X9035A2	56289	0180-0291	1
CR10-14	Diode, Si 200mA 75V	5		28480	1901-0050	5
L1	Ferrite Bead	1		28480	9170-0847	1
Q10	SS PNP Si	3		28480	1853-0099	3
Q11	Dual NPN Si	1		28480	1854-0221	1
Q12	SS NPN Si	2		28480	1854-0071	2
Q13	SS NPN Si	1		28480	1854-0087	1
Q14	SS NPN Si	1		28480	5080-7132	1
Q15,30	SS PNP Si			28480	1853-0099	
Q31	SS NPN Si	2		28480	1854-0244	2
Q32	SS NPN Si			28480	1854-0071	
Q40	SS NPN Si			28480	1854-0244	
R10	fxd, comp 82KΩ ±5%, 1/2W	1	EB-8235	01121	0686-8235	1 Chg
R11	fxd, comp 3KΩ ±5%, 1/2W	1	EB-3025	01121	0686-3025	1 Chg
R12	fxd, met. film 1KΩ ±1%, 1/4W	1	Type CCA T-O	07716	0757-0338	1 OK
R13	fxd, comp 5.6KΩ ±5%, 1/2W	1	EB-5625	01121	0686-5625	1 CHG
R14	fxd, met. film 110KΩ ±1%, 1/8W	1	MF4C-TO	30983	0757-0466	1 chg
R15	fxd, met. film 160KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0698-5092	1 OK
R16	fxd, ww 297Ω ±1%, 1/4W 20ppm	1	Type R303B	01686	0811-1929	1
R17	fxd, ww 243Ω ±1%, 1/4W 20ppm	1	Type R303B	01686	0811-2075	1
R18	var. ww 500Ω (Type 100)	1	Model 100	11502	2100-0898	1
R19	fxd, ww 10KΩ ±0.1%, TC ±2ppm	1	Type 7007	01686	0811-2577	1
R20A	fxd, ww 10KΩ ±0.1% (Matched to R20B)	1	Type 135F	20940	0811-2572	1
R20B	fxd, ww 15.82KΩ ±0.1%	1	Type 135F	26940	0811-2572	1
R21	fxd, comp 1.8KΩ ±5%, 1/2W	1	EB-1825	01121	0686-1825	1
R22	fxd, met. film 7.5KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0757-0440	1
R23	fxd, met. film 12KΩ ±1%, 1/8W	2	Type CEA T-O	07716	0698-5088	1
R24	fxd, comp 2.2KΩ ±5%, 1/2W	2	EB-2225	01121	0686-2225	1
R25	fxd, met. film 12KΩ ±1%, 1/8W		Type CEA T-O	07716	0698-5088	
R26	fxd, comp 2KΩ ±5%, 1/2W	1	EB-2025	01121	0686-2025	1
R27	fxd, met. film 600Ω ±1%, 1/8W	1	Type CEA T-O	07716	0757-1100	1
R30	fxd, met. film 2KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0757-0283	1
R31	fxd, comp 51Ω ±5%, 1/2W	1	EB-5105	01121	0686-5105	1
R34A	fxd, ww 2350Ω ±0.1% (Match to R34B)	1	Type 7007	01686	0811-1167	1
R34B	fxd, ww 1940Ω ±0.1%	1	Type 7007	01686	0811-1167	1
R36	var. ww 100Ω ±5%	9	Model 100	11502	2100-1450	2
R40	fxd, comp 1.2KΩ ±5%, 1/2W	1	EB-1225	01121	0686-1225	1
R50	fxd, met. film 196Ω ±1%, 1/8W	1	Type CEA T-O	07716	0698-3440	1
R51	fxd, comp 18Ω ±5%, 1/2W	1	EB-1805	01121	0686-1805	1
R52-59	var. ww 100Ω ±5%		Model 100	11502	2100-1450	
R60	fxd, ww 19.96KΩ ±.1%, TC ±2ppm	1	Type 7007	01686	0811-2574	1
R61-67	fxd, ww 19.96KΩ ±.1%, TC ±5ppm	7	Type 7007	01686	0811-2575	2
R68-76	fxd, ww 10KΩ ±.1%, TC ±5ppm	9	Type E30	01686	0811-1994	2
R77,78,79	fxd, met. film 10KΩ ±1%, 1/8W	3	Type CEA T-O	07716	0757-0442	1
R80-86	fxd, ww 20KΩ ±.1% TC ±5ppm	7	Type 7007	01686	0811-2609	2
R87-91	fxd, met. film 20KΩ ±1%, 1/8W	5	Type CEA T-O	07716	0757-0449	1
R92	fxd, ww 90KΩ ±.1% TC ±5ppm	1	135F	20940	0811-2570	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A3R93	fxd, ww 100KΩ ±.1%, TC ±5ppm	1	Type 7010	01686	0811-1997	1
R94	fxd, ww 1124Ω ±.1%, TC ±5ppm	1	135F	20940	0811-2573	1
R95	fxd, met. film 562KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0757-0483	1
R96	fxd, met. film 600Ω ±1%, 1/8W	1	MF4C T-O	30983	0757-1100	1
R97	fxd, met. film 11KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0757-0443	1
R98	fxd, met. film 1MΩ ±1%, 1/4W	1	Type CEB T-O	07716	0757-0344	1
R99	fxd, met. film 221KΩ ±1%, 1/8W	1	MF4C T-O	30983	0757-0473	1
R100	var. ww 15KΩ ±5%	1	Model 100	11502	2100-0896	1
R102	NOT ASSIGNED	-		--	--	-
R103	fxd, comp 5.6KΩ ±5%, 1/2W	1	EB-5625	01121	0686-5625	1
VR30	Diode, zener 4.22V 400mW	1		28480	1902-3070	1
VR31	Diode, zener 12.4V 400mW	1		28480	1902-3185	1
VR40	Diode, zener 6.19V 400mW	1	CD35646	07910	1902-0049	1
C1 & C2	5600 uf 25V	2			0180-1921	2
A4	Power Supply Board	1		28480	06131-60023	
~~C1~~-3 C3	NOT ASSIGNED 4000uf 15VDC	1			0180-2385	1
C4, 5	fxd, elect. 1,450µF 45Vdc OK	2		28480	0180-1893	1
C6, 7	NOT ASSIGNED 430uf 200V	2			0180-1808	2
C8, 9	fxd, elect. 200µF 175Vdc OK	2		28480	0180-1885	1
C10	fxd, elect. 100µF 25Vdc	1	30D107G025DD2	56289	0180-0094	1
C11-C22	fxd, ceramic .05µF 400V	4	33C 17A CDH	56289	0150-0052	1
C23	fxd, elect. 100µF 25Vdc		30D107G025DD2	28480	0180-0094	
CR1-4	Rect. Si 1A 400 prv	18		28480	1901-0328	8
CR5,6,7	Rect. Si 250mW 200 prv	4	1N485B	03877	1901-0033	4
CR8-21	Rect. Si 1A 400 prv			28480	1901-0328	
CR22	Rect. Si. 250mW 200 prv		1N485B	03877	1901-0033	
K1	Relay, 6Vdc	1	643-6V	09023	0490-0513	
Q1	SS PNP Si.	1		28480	1853-0099	1
R1-R3	fxd, comp 560Ω ±5%, 1/2W	3	EB-5615	01121	0686-5615	1
R4, 5	fxd, comp 3.3KΩ ±5% 1/2W	3	EB-3325	01121	0686-3325	1
R6, 7	fxd, met. oxide 33KΩ ±5% 2W	2	Type C42S	16299	0764-0046	1
R8, 9	fxd, comp 51KΩ ±5% 1W	2	GB-5135	01121	0689-5135	1
R10	fxd, comp 3KΩ ±5% 1/2W	1	EB-3025	01121	0686-3025	1
R11	fxd, comp 3.6KΩ ±5% 1/2W	1	EB-3625	01121	0686-3625	1
R12	fxd, comp 9.1KΩ ±5% 1/2W	1	EB-9125	01121	0686-9125	1
R13	fxd, comp 33KΩ ±5% 1/2W		EB-3325	01121	0686-3325	
R14	var. ww 5KΩ ±5%	1	Type CT-100-4	11236	2100-0741	1
R15	fxd, film 6.2KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-5087	1
R16	fxd, film 6KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-3476	1
R17	fxd, film 20.0KΩ ±1% 1/8W	1	Type CEA T-0	07716	0757-0449	1
R18	fxd, film 118KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-3265	1
R19	fxd, film 1KΩ ±1% 1/8W	1	Type CEA T-0	07716	0757-0280	1
R20	fxd, film 197Ω ±1% 1/4W	1	Type R303B	01686	0811-1925	1
R21	fxd, film 10Ω ±1% 1/8W	1	Type CEA T-0	07716	0757-0346	1
R22	fxd, film 42.2Ω ±1% 1/8W	2	Type CEA T-0	07716	0757-0316	1
R23	Thermistor 64Ω ±10%	1	LB16J1	02606	0837-0023	1
R24	var. ww 10Ω ±5%	1	Type CT-100-4	06486	2100-1767	1
A4R25	fxd, film 42.2Ω ±1% 1/8W		Type CEA T-0	07716	0757-0316	
R26	fxd, comp 200Ω ±5% 1/2W	1	EB-2015	01121	0686-2015	1
R27	fxd, comp 2KΩ ±5% 1/2W	1	EB-2025	01121	0686-2025	1
T1	NOT ASSIGNED					
T2	Bias Transformer	1		28480	5080-1773	
A5	Interconnect Board	1		09182	06131-60024	
C1	fxd, film 0.01µF 200Vdc	1	192P10392	56289	0160-0161	1
C2	fxd, tant. 4.7µF 35Vdc	1	150D475X9035B2-DYS	56289	0180-0100	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A5C3	fxd, ceramic 0.1µF 50Vdc	1	5C50B1-CML	56289	0150-0121	1
CR1-8	Rect. Si. 1A 200 prv	8		28480	1901-0327	
J1-J6	P.C. Board Edge Connectors	6	252-22-30-340	71785	1251-1887	2
L1	Inductor 1µH	1		28480	9100-2198	1
R3, 4	fxd, ww 2.7Ω ±5% 2W	3	Type BWH	07716	0811-1671	1
R5	fxd, ww 1.25Ω ±1% 4W	1	NS-2-18	91637	0811-2556	1
R6, 7	fxd, comp 100Ω ±5% 1/2W	2	EB-1015	01121	0686-1015	1
R8	fxd, comp 4.7Ω ±5% 1/2W	1	EB-0001	01121	0698-0001	1
R9	fxd, ww 2.7Ω ±5% 2W		Type BWH	07716	0811-1671	
R10	fxd, film 4KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-5808	1
R11	fxd, film 1KΩ ±1% 1/8W	1	Type CEA T-0	07716	0757-0280	
R12	fxd, ww 10KΩ ±0.1% 1/4W	1	Type E30	01686	0811-1994	1
A6	Control Board		Refer to proper Option Appendix			
A6A1	Input Isolator Circuit					
CR1,2	Diode, Si 200mA 75V	2		28480	1901-0050	2
Q1,2	SS NPN Si	2		28480	1854-0071	2
R1,2,3			Refer to proper Option Appendix			
R4	fxd, comp 750Ω ±5%, 1/2W	1	EB-7515	01121	0686-7515	1
R5	fxd, comp 82Ω ±5%, 1/4W	1	CB-8205	01121	0683-8205	1
R6	fxd, comp 750Ω ±5%, 1/4W	1	CB-7515	01121	0683-7515	1
Z1	Photo-Isolator	1		28480	1990-0407	1
A6A2 through A6A4	Same as A6A1					
A6A5	Latch Status Isolator and Output Amplifier					
CR1,2	Diode, Si 200mA 75V	2		28480	1901-0050	2
Q1-4	SS NPN Si	4		28480	1854-0071	4
R1	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
R2	fxd, comp 1.3KΩ ±5%, 1/2W	1	EB-1325	01121	0686-1325	1
R3	fxd, comp 750Ω ±5%, 1/2W	1	EB-7515	01121	0683-7515	1
R4	fxd, comp 82Ω ±5%, 1/4W	1	CB-8205	01121	0683-8205	1
R5	fxd, comp 12KΩ ±5%, 1/4W	1	CB-1235	01121	0683-1235	1
R6	fxd, comp 100Ω ±5%, 1/4W	1	CB-1015	01121	0683-1015	1
R7	fxd, comp 5.6KΩ ±5%, 1/2W	1	EB-5625	01121	0686-5625	1
R8			Refer to proper Option Appendix			
VR1			Refer to proper Option Appendix			
Z1	Photo-Isolator	1		28480	1900-0407	1
A6A6	Overload Status Isolator and Output Amplifier					
CR1,2	Diode, Si 200ma 75V	2		28480	1901-0050	2
Q1-3	SS NPN Si	3		28480	1854-0071	3
Q4			Refer to Instrument Modification Sheet			
R1	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
R2	fxd, comp 1.3KΩ ±5%, 1/2W	1	EB-1325	01121	0686-1325	1
R3	fxd, comp 750Ω ±5%, 1/2W	1	EB-7515	01121	0683-7515	1
R4	fxd, comp 82Ω ±5%, 1/4W	1	CB-8205	01121	0683-8205	1
R5	fxd, comp 12KΩ ±5%, 1/4W	1	CB-1235	01121	0683-1235	1
R6	fxd, comp 100Ω ±5%, 1/4W	1	CB-1015	01121	0683-1015	1
R7			Refer to Instrument Modification Sheet			
R8			Refer to proper Option Appendix			
VR1			Refer to proper Option Appendix			
Z1	Photo-Isolator	1		28480	1900-0407	1
A6C1	fxd, mica 240pF 300Vdc	4	RDM15F241J3C	00853	0140-0199	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A6C2	fxd, ceramic .47μF 25Vdc	2	5C11B7	56289	0160-0174	1
C3	fxd, mica 30pF 300Vdc	1	RDM15E300J3C	00853	0160-2199	1
C4	fxd, mylar .001μF 200Vdc	3	192P10292	56289	0160-0153	1
C5,6,7	fxd, mica 240pF 300Vdc		RDM15F241J3C	00853	0140-0199	
C8	fxd, mylar 2200pF 200Vdc	1	192P22292	56289	0160-0154	1
C9,10	fxd, mylar .001μF 200Vdc		192P10292	56289	0160-0153	
C11	fxd, mylar .033μF 200Vdc	1	192P33392	56289	0160-0163	1
C12	fxd, mica 150pF 300Vdc	1	RDM15F151J3C	00853	0140-0196	1
C13,14	fxd, mica 390pF 300Vdc	2	RDM15F391J3C	00853	0140-0200	1
C15	fxd, ceramic .1μF 50Vdc	1	5C50B1-CML	56289	0150-0121	1
C16	fxd, tant. 4.7μF 35Vdc	1	150D475X9035B2-DYS	56289	0180-0100	1
C17	fxd, ceramic .47μF 25Vdc		5C11BC	56289	0160-0174	
CR1,2	Diode, Si 200mA 75V	17		28480	1901-0050	8
CR5-13	Diode, Si 200mA 75V			28480	1901-0050	
CR14,15			Refer to proper Option Appendix			
CR16-18	Diode, Si 200mA 75V			28480	1901-0050	
CR19	Stabistor, Si 10prv 400mW	1		28480	1901-0460	1
CR20	Diode, Si 200mA 75V			28480	1901-0050	
A6Q1,2,3	SS NPN Si	17		28480	1854-0071	8
Q4	SS NPN Si	6	2N3417	03508	1854-0087	5
Q5,6	SS NPN Si			28480	1854-0071	
Q8-13	SS PNP Si	9		28480	1853-0099	5
Q14,15	SS NPN Si			28480	1854-0071	
Q16-18	SS NPN Si		2N3417	03508	1854-0087	
Q19,20	SS PNP Si			28480	1853-0099	
Q21,22	SS NPN Si		2N3417	03508	1854-0087	
Q23	SS PNP Si			28480	1853-0099	
Q24-33	SS NPN Si			28480	1854-0071	
Q34	Power NPN Si	1	2N1711	17803	1854-0003	1
R1-3	fxd, comp 3.9KΩ ±5%, 1/4W	3	CB-3925	01121	0683-3925	1
R4-6	fxd, comp 39KΩ ±5%, 1/4W	3	CB-3935	01121	0683-3935	1
R7	fxd, ww 220Ω ±5%, 2W	1	Type BWH	07716	0811-1763	1
R8-10	fxd, comp 5.1KΩ ±5%, 1/4W	9	CB-5125	01121	0683-5125	1
R11-13	fxd, comp 9.1KΩ ±5%, 1/4W	3	CB-9125	01121	0683-9125	1
R14,15	fxd, comp 20KΩ ±5%, 1/4W	12	CB-2035	01121	0683-2035	2
R16-18	fxd, film 19.6KΩ ±1%, 1/8W	3	Type CEA T-O	07716	0698-3157	1
R19	var, cermet 1KΩ ±10%	1	62-224-1	73138	2100-2633	1
R20,21	var, cermet 200Ω ±10%	2	62-222-1	73138	2100-2413	1
R22-24	fxd, film 3.57KΩ ±1%, 1/8W	3	Type CEA T-O	07716	0698-3496	1
R25,26	fxd, comp 200Ω ±5%, 1/4W	2	CB-2015	01121	0683-2015	1
R27	fxd, film 6KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0698-3476	1
R28	fxd, film 2.37KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0698-3150	1
R29	fxd, film 4KΩ ±1%, 1/8W	1	Type CEA T-O	07716	0698-5808	1
R30	fxd, film 121Ω ±1%, 1/8W	2	Type CEA T-O	07716	0757-0069	1
R31,32	fxd, film 432KΩ ±1%, 1/8W	2	Type CEA T-O	07716	0757-0480	1
R33,34	fxd, film 1KΩ ±1%, 1/8W	4	Type CEA T-O	07716	0757-0280	1
R35,36	fxd, film 10KΩ ±1%, 1/8W	3	Type CEA T-O	07716	0757-0442	1
R37	fxd, film 121Ω ±1%, 1/8W		Type CEA T-O	07716	0757-0069	
R38	fxd, film 750Ω ±5% 1/4W	2	CB-7515	01121	0683-7515	1
R39	fxd, film 1KΩ ±1%, 1/8W		Type CEA T-O	07716	0757-0280	
R40	fxd, comp 2.4KΩ ±5%, 1/4W	1	CB-2425	01121	0683-2425	1
R41	fxd, comp 5.1KΩ ±5%, 1/4W		CB-5125	01121	0683-5125	
R42	fxd, film 8.2KΩ ±2%, 1/8W	2	Type CEA T-O	07716	0757-0946	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A6R43	fxd, film 1KΩ ±1%, 1/8W		Type CEA T-O	07716	0757-0280	
R44	fxd, film 182Ω ±1%, 1/8W	1	Type CEA T-O	07716	0757-0406	1
R45	fxd, film 8.2KΩ ±2%, 1/8W		Type CEA T-O	07716	0757-0946	
R46	fxd, film 11KΩ ±1% 1/8W	1	Type CEA T-O	07716	0757-0443	1
R47	fxd, film 1.3KΩ ±1%, 1/4W	1	Type CEB T-O	07716	0757-0735	1
R48	fxd, film 1.21KΩ ±1%, 1/4W	1	Type CEB T-O	07716	0757-0734	1
R49	fxd, comp 5.1KΩ ±5%, 1/4W		CB-5125	01121	0683-5125	
R50-52	fxd, comp 10KΩ ±5%, 1/4W	9	CB-1035	01121	0683-1035	1
R53,54	fxd, comp 20KΩ ±5%, 1/4W		CB-2035	01121	0683-2035	
R55,56	fxd, comp 10KΩ ±5%, 1/4W		CB-1035	01121	0683-1035	
R57,58	fxd, comp 2KΩ ±5%, 1/4W	3	CB-2025	01121	0683-2025	1
R59	fxd, comp 5.1KΩ ±5%, 1/4W		CB-5125	01121	0683-5125	
R60	fxd, comp 10KΩ ±5%, 1/4W		CB-1035	01121	0683-1035	
R61-63	fxd, comp 20KΩ ±5%, 1/4W		CB-2035	01121	0683-2035	
R64,65	fxd, comp 5.1KΩ ±5%, 1/4W		CB-5125	01121	0683-5125	
R66	fxd, comp 100Ω ±5%, 1/4W	1	CB-1015	01121	0683-1015	1
R67	fxd, comp 1KΩ ±5%, 1/4W	2	CB-1025	01121	0683-1025	1
R73	fxd, comp 4.7KΩ ±5%, 1/4W	2	CB-4725	01121	0683-4725	1
R74	fxd, comp 20KΩ ±5%, 1/4W		CB-2035	01121	0683-2035	
R75	fxd, comp 6.2KΩ ±5%, 1/4W	3	CB-6225	01121	0683-6225	1
R76	fxd, comp 100KΩ ±5%, 1/4W	2	CB-1045	01121	0683-1045	1
R77	fxd, comp 5.6KΩ ±5%, 1/4W	1	CB-5625	01121	0683-5625	
R78	fxd, comp 4.7KΩ ±5%, 1/4W		CB-4725	01121	0683-4725	
R79	fxd, comp 2KΩ ±5%, 1/4W		CB-2025	01121	0683-2025	
R80	fxd, comp 20KΩ ±5%, 1/4W		CB-2035	01121	0683-2035	
R81	fxd, comp 2.7KΩ ±5%, 1/4W	1	CB-2725	01121	0683-2725	1
R82	fxd, comp 1KΩ ±5%, 1/4W		CB-1025	01121	0683-1025	
R83	fxd, comp 200KΩ ±5%, 1/4W	1	CB-2045	01121	0683-2045	1
R84	fxd, comp 5.1KΩ ±5%, 1/4W		CB-5125	01121	0683-5125	
R85	fxd, comp 33KΩ ±5%, 1/4W	1	CB-3335	01121	0683-3335	1
R86	fxd, comp 82KΩ ±5%, 1/4W	1	CB-8235	01121	0683-8235	1
R87	fxd, comp 3.6KΩ ±5%, 1/4W	1	CB-3625	01121	0683-3625	1
R88	fxd, comp 9.1KΩ ±5%, 1/4W	1	CB-9125	01121	0683-9125	1
R89,90	fxd, comp 6.2KΩ ±5%, 1/4W		CB-6225	01121	0683-6225	
R91	fxd, comp 100KΩ ±5%, 1/4W		CB-1045	01121	0683-1045	
R92	fxd, comp 12KΩ ±5%, 1/4W	1	CB-1235	01121	0683-1235	1
R93,94,95	fxd, comp 20KΩ ±5%, 1/4W		CB-2035	01121	0683-2035	
R96	fxd, comp 1.3KΩ ±5%, 1/2W		EB-1325	01121	0686-1325	
R97	fxd, comp 51KΩ ±5%, 1/4W	1	CB-5135	01121	0683-5135	1
R98	fxd, comp 750Ω ±5%, 1/4W		CB-7515	01121	0683-7515	
R99	fxd, comp 82Ω ±5%, 1/4W		CB-8205	01121	0683-8205	
R100,101	fxd, comp 10KΩ ±5%, 1/4W		CB-1035	01121	0683-1035	
R102	fxd, ww 390Ω ±5%, 3W	1	242E	56289	0811-1799	1
R103	fxd, comp 10KΩ ±5%, 1/4W		CB-1035	01121	0683-1035	
R105	fxd, comp 10Meg ±5%, 1/4W	1	CB-1065	01121	0683-1065	1
R106	fxd, film 10KΩ ±1%, 1/8W		Type CEA T-O	07716	0757-0442	
R107	fxd, comp 5.6Meg ±5%, 1/4W	1	CB-5655	01121	0683-5655	1
R108	var, cermet 20KΩ ±10%	1	62-228-1	73138	2100-2514	1
R109	fxd, ww 75Ω ±5%, 5W	1	243E	56289	0812-0097	1
VR1	Diode, zener 4.99V 400mW	1		28480	1902-3092	1
VR2	Diode, zener 12.4V 400mW	1		28480	1902-3185	1
VR4-6	Diode, zener 4.22V 400mW	3		28480	1902-3070	3
Z1	Hybrid Resistive Network IC	1		28480	1810-0041	1
Z2	Quad 4-Bit Bistable Latch IC	1	SN7475	01295	1820-0876	1
Z3	Operational Amplifier IC	1	SL8641	27014	1820-0223	1
Z4	Dual Operational Amp	1		28480	1826-0092	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A7	Amplifier Plug-In Board	1		09182	06131-60022	
C1	fxd, mica 330pF 500Vdc	2	RCM15E331J	84171	0140-0168	1
C2,3	fxd, mylar 0.22μF 80Vdc	2	192P2249R8	56289	0160-2453	1
C4	fxd, elect. 1μF 35Vdc	1	150D105X9035A2	56289	0180-0291	1
C5,6	fxd, mylar 0.0022μF 200V	4	192P22292	56289	0160-0154	1
C7,8	fxd, elect. 0.47μF 35Vdc	3	150D474X9035A2	56289	0180-0376	1
C9	fxd, mylar 0.0022μF 200V		192P22292	56289	0160-0154	
C10	fxd, mylar 0.0047μF 200Vdc	3	192P47292	56289	0160-0157	1
C11	fxd, mylar 0.0022μF 200V		192P22292	56289	0180-0154	
C12	fxd, mylar 0.0047μF 200Vdc		192P47292	56289	0160-0157	
C13	fxd, ceramic 0.001μF 500Vdc	4 ~~3~~	40C88A1	56289	0160-3398	1
C14	~~NOT ASSIGNED~~ Same As C13		ADDED		0160-3398	
C15	fxd, mylar 0.01μF 200Vdc	1	192P10392	56289	0160-0161	1
C16	fxd, mylar 0.022μF 200Vdc	2	192P22392	56289	0160-0162	1
C17	fxd, mica 330pF 500Vdc		RCM15E331J	84171	0140-0168	
C18	fxd, elect. 0.47μF 35Vdc		150D474X9035A2	56289	0180-0376	
C19	fxd, ceramic 0.001μF 500Vdc		40C88A1	56289	0160-3398	
C20	fxd, ceramic 100pF 1KVdc	1	DD-101	71590	0160-2061	1
C21	fxd, ceramic 0.001μF 500Vdc		40C88A1	56289	0160-3398	
C22	fxd, mylar 0.0033μF 200V	1		09182	0160-0155	1
C23	fxd, mylar 0.022μF 200Vdc		192P22392	56289	0160-0162	
C24,25	fxd, ceramic 0.47μF 25Vdc	2	5C11B7	56289	0160-0174	1
C26	fxd, elect. 5μF 150Vdc	1	40D505F150DC4	56289	0180-1841	1
C27	fxd, mylar 0.0047μF 200Vdc		192P47292	56289	0160-0157	
C28 C29	fxd, mylar 0.01μF 400Vdc .0033uf, 200V	1	663UW	84411	0160-0381 0160-0155	1 ADD
CR1-CR14	Diode, Si. 15V 400mW	20		09182	1901-0461	8
CR15	Diode, Si. 75V 200mA	17		09182	1901-0050	8
CR16,17	Stabistor, Si. 10prv	3		09182	1901-0460	3
CR18	Diode, Si. 15V 400mW			09182	1901-0461	
CR19,20	Diode, Si. 75V 200mA			09182	1901-0050	
CR21	Stabistor, Si. 10prv			09182	1901-0460	
CR22	Diode, Si. 15V 400mW			09182	1901-0461	
CR23	Diode, Si. 75V 200mA			09182	1901-0050	
CR24-CR27	Diode, Si. 15V 400mW			09182	1901-0461	
CR28-CR40	Diode, Si. 75V 200mA			09182	1901-0050	
K1	Reed Relay and Coil Assembly	1		09182	5080-7127	1
	Reed Relay (Part of K1)	1	DRS-2	12617	0490-0727	1
	Coil (Part of K1)	1	SF12P	71707	0490-0728	1
K2	Reed Relay	1		09182	0490-0399	1
Q1	Diff. Amp, NPN	1		09182	1854-0221	1
Q2	Diff. Amp, NPN	1		09182	1854-0229	1
Q3,4	SS NPN Si.	7	2N3417	03508	1854-0087	7
Q5	SS PNP Si.	1		09182	1853-0010	1
Q6	SS PNP Si.	1		09182	1853-0038	1
Q7	SS NPN Si.	1		09182	1854-0232	1
Q8	SS NPN Si.	2		09182	1854-0071	2
Q9	SS PNP Si.	5		09182	1853-0099	5
Q10,11	SS NPN Si.	6		09182	1854-0271	6
Q12,13	SS PNP Si.	6		09182	1853-0037	6
Q14,15	SS NPN Si.			09182	1854-0271	
Q16,17	SS PNP Si.			09182	1853-0037	
Q18,19	SS NPN Si.		2N3417	03508	1854-0087	
Q20-Q22	SS PNP Si.			09182	1853-0099	
Q23,24,25	SS NPN Si.		2N3417	03508	1854-0087	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A7Q26	SS PNP Si.	1	40362	02735	1853-0041	1
Q27	SS NPN Si.			09182	1854-0071	
Q28	SS NPN Si.	1		09182	1854-0244	1
Q29	SS PNP Si.			09182	1853-0099	
Q30,31	SS NPN Si.			09182	1854-0271	
Q32,33	SS PNP Si.			09182	1853-0037	
R1	fxd, film 1MΩ ±1% $\frac{1}{4}$W	1	Type CEB T-0	07716	0757-0344	1
R2	fxd, film 45KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-5091	1
R3	fxd, film 619Ω ±1% $\frac{1}{4}$W	1	Type CEB T-0	07716	0757-0728	1
R4,5	fxd, film 200KΩ ±1% 1/8W	2	Type CEA T-0	07716	~~0757-0472~~ 0698-8004	1
R6	fxd, comp 1KΩ ±5% $\frac{1}{2}$ W	4	EB-1025	01121	0686-1025	1
R7	fxd, film 4.75KΩ ±1% 1/8W	1	Type CEA T-0	07716	0757-0437	1
R8	fxd, film 118KΩ ±1% 1/8W	1	Type CEA T-0	07716	0698-3265	1
R9	var. ww 100Ω ±5%	1	Type 100	11502	2100-~~1450~~ - 0558-1770	1
R10,11	fxd, film 21.5Ω ±1% 1/8W	2	Type CEA T-0	07716	0698-3430	1
R12,13	fxd, film 43KΩ ±1% 1/8W	2	Type CEA T-0	07716	0698-5090	1
R14,15	fxd, film 12KΩ ±1% 1/8W	3	Type CEA T-0	07716	0698-5088	1
R16	fxd, comp 1KΩ ±5% $\frac{1}{2}$ W		EB-1025	01121	0686-1025	
R17,18	fxd, film 510Ω ±1% $\frac{1}{4}$W	2	Type CEB T-0	07716	0698-5145	1
R19	fxd, comp 100Ω ±5% $\frac{1}{2}$ W	2	EB-1015	01121	0686-1015	1
R20	fxd, film 12KΩ ±1% 1/8W		Type CEA T-0	07716	0698-5088	
R21	fxd, comp 1.3KΩ ±5% $\frac{1}{2}$ W	2	EB-1325	01121	0686-1325	1
R22,23	fxd, comp 51Ω ±5% $\frac{1}{2}$ W	2	EB-5105	01121	0686-5105	1
R24	fxd, comp 5.6KΩ ±5% $\frac{1}{2}$ W	1	EB-5625	01121	0686-5625	1
R25	fxd, comp 560Ω ±5% $\frac{1}{2}$ W	3	EB-5615	01121	0686-5615	1
R26	fxd, comp 510Ω ±5% $\frac{1}{2}$ W	2	EB-5115	01121	0686-5115	1
R27	fxd, comp 3KΩ ±5% $\frac{1}{2}$ W	1	EB-3025	01121	0686-3025	1
R28	fxd, comp 5.1KΩ ±5% $\frac{1}{2}$ W	4	EB-5125	01121	0686-5125	1
R29	fxd, comp 1KΩ ±5% $\frac{1}{2}$ W		EB-1025	01121	0686-1025	
R30	fxd, comp 1.2KΩ ±5% $\frac{1}{2}$ W	1	EB-1225	01121	0686-1225	1
R31	fxd, comp 2KΩ ±5% $\frac{1}{2}$ W	3	EB-2025	01121	0686-2025	1
R32	fxd, comp 36KΩ ±5% $\frac{1}{2}$ W	2	EB-3635	01121	0686-3635	1
R33	fxd, comp 2KΩ ±5% $\frac{1}{2}$ W		EB-2025	01121	0686-2025	
R34	fxd, comp 36KΩ ±5% $\frac{1}{2}$ W		EB-3635	01121	0686-3635	
R35	fxd, comp 180KΩ ±5% $\frac{1}{2}$ W	2	EB-1845	01121	0686-1845	1
R36	fxd, comp 910Ω ±5% $\frac{1}{2}$ W	1	EB-9115	01121	0686-9115	1
R37	fxd, comp 180KΩ ±5% $\frac{1}{2}$ W		EB-1845	01121	0686-1845	
R38	fxd, met. oxide 36KΩ ±5% 2W	1	Type C42S	16299	0698-3651	1
R39	NOT ASSIGNED	-	-	-	-	-
R40	fxd, comp 2.7KΩ ±5% $\frac{1}{2}$ W	2	EB-2725	01121	0686-2725	1
R41	fxd, comp 10Ω ±5% $\frac{1}{2}$ W	2	EB-1005	01121	0686-1005	1
R42	fxd, comp 5.11KΩ ±5% $\frac{1}{2}$ W		EB-5125	01121	~~0686-5125~~ 0757-0438	
R43	fxd, comp 510Ω ±5% $\frac{1}{2}$ W		EB-5115	01121	0686-5115	
R44	fxd, comp 8.2KΩ ±5% $\frac{1}{2}$ W	2	EB-8225	01121	0686-8225	1
R45	fxd, film 221KΩ ±1% 1/8W	2	Type CEA T-0	07716	0757-0473	1
R46	fxd, film 825Ω ±1% 1/8W	2	Type CEA T-0	07716	0757-0421	1
R47	fxd, film 7.5KΩ ±1% 1/8W	2	Type CEA T-0	07716	0757-0440	1
R48	fxd, comp 1.5KΩ ±5% $\frac{1}{2}$ W	3	EB-1525	01121	0686-1525	1
R49	fxd, comp 27KΩ ±5% $\frac{1}{2}$ W	3	EB-2735	01121	0686-2735	1
R50	fxd, comp 1.5KΩ ±5% 1W	2	GB-1325	01121	~~0689-1325~~ 0757-0197	1
R51	NOT ASSIGNED					
R52	fxd, comp 2.7KΩ ±5% $\frac{1}{2}$ W		EB-2725	01121	0686-2725	
R53	fxd, comp 10Ω ±5% $\frac{1}{2}$ W		EB-1005	01121	0686-1005	
R54	fxd, comp 5.11KΩ ±5% $\frac{1}{2}$ W		EB-5125	01121	~~0686-5125~~ 0757-0438	
R55	fxd, comp 100Ω ±5% $\frac{1}{2}$ W		EB-1015	01121	0686-1015	
R56	fxd, comp 2KΩ ±5% $\frac{1}{2}$ W		EB-2025	01121	0686-2025	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A7R57	fxd, film 221KΩ ±1% 1/8W		Type CEA T-0	07716	0757-0473	
R58	fxd, film 825Ω ±1% 1/8W		Type CEA T-0	07716	0757-0421	
R59	fxd, film 7.5KΩ ±1% 1/8W		Type CEA T-0	07716	0757-0440	
R60	fxd, comp 27KΩ ±5% $\frac{1}{2}$ W		EB-2735	01121	0686-2735	
R61	NOT ASSIGNED					
R62	fxd, comp 1.5KΩ ±5% 1W		GB-1325	01121	~~0689-1325~~ 0757-0197	
R63	fxd, comp 1.5KΩ ±5% $\frac{1}{2}$ W		EB-1525	01121	0686-1525	
R64	fxd, comp 4.3KΩ ±5% $\frac{1}{2}$ W	4	EB-4325	01121	0686-4325	1
R65	fxd, comp 1.5KΩ ±5% $\frac{1}{2}$ W		EB-1525	01121	0686-1525	
R66	NOT ASSIGNED					
R67	fxd, comp 10KΩ ±5% $\frac{1}{2}$ W	2	EB-1035	01121	0686-1035	1
R68	fxd, comp 27KΩ ±5% $\frac{1}{2}$ W		EB-2735	01121	0686-2735	
R69	fxd, comp 39KΩ ±5% $\frac{1}{2}$ W	1	EB-3935	01121	0686-3935	1
R70	fxd, comp 150Ω ±5% $\frac{1}{2}$ W	1	EB-1515	01121	0686-1515	1
R71	fxd, comp 4.3KΩ ±5% $\frac{1}{2}$ W		EB-4325	01121	0686-4325	
R72	fxd, comp 10KΩ ±5% $\frac{1}{2}$ W		EB-1035	01121	0686-1035	
R73	fxd, comp 4.3KΩ ±5% $\frac{1}{2}$ W		EB-4325	01121	0686-4325	
R74	fxd, comp 750Ω ±5% $\frac{1}{2}$ W	3	EB-7515	01121	0686-7515	1
R75	fxd, comp 7.5KΩ ±5% $\frac{1}{2}$ W	2	EB-7525	01121	0686-7525	1
R76	fxd, comp ~~560Ω~~ ±5% $\frac{1}{2}$ W 820Ω		EB-5615	01121	0686-~~5615~~ 8215	
R77	fxd, film ~~6.2KΩ~~ ±1% 1/8W 5.62K	2	Type CEA T-0	07716	~~0698-5087~~ 0757-0200	1
R78	fxd, film 4.53KΩ ±1% 1/8W	2	Type CEA T-0	07716	0698-4443	1
R79	fxd, comp 4.3KΩ ±5% $\frac{1}{2}$ W		EB-4325	01121	0686-4325	
R80	fxd, comp 750Ω ±5% $\frac{1}{2}$ W		EB-7515	01121	0686-7515	
R81	fxd, comp 7.5KΩ ±5% $\frac{1}{2}$ W		EB-7525	01121	0686-7525	
R82	fxd, comp ~~560Ω~~ ±5% $\frac{1}{2}$ W 820Ω		EB-5615	01121	0686-~~5615~~ 8215	
R83	fxd, film ~~6.2KΩ~~ ±1% 1/8W 5.62K		Type CEA T-0	07716	~~0698-5087~~ 0757-020	
R84	fxd, film 4.53KΩ ±1% 1/8W		Type CEA T-0	07716	0698-4443	
R85	var. ww 200Ω ±10%	1	Type 500	11502	2100-~~1771~~ 3212	
R86	fxd, ww 89.9KΩ ±0.1% 2ppm	1	1367	01686	0811-2900	1
R87	fxd, ww 10KΩ ±0.1% 5ppm	1	Type E30	01686	0811-1994	1
R88	fxd, comp 8.2KΩ ±5% $\frac{1}{2}$ W		EB-8225	01121	0686-8225	
R89	fxd, comp 1.3KΩ ±5% $\frac{1}{2}$ W		EB-1325	01121	0686-1325	
R90	fxd, comp 5.1KΩ ±5% $\frac{1}{2}$ W		EB-5125	01121	0686-5125	
R91	fxd, comp 2KΩ ±5% 1W	1	GB-2025	01121	0689-2025	1
R92,93	NOT ASSIGNED					
R94	fxd, comp 820Ω ±5% $\frac{1}{2}$ W	1	EB-8215	01121	0686-8215	1
R95	NOT ASSIGNED					
R96	fxd, comp 200Ω ±5% $\frac{1}{2}$ W	5	EB-2015	01121	0686-2015	1
R97	fxd, comp 39Ω ±5% $\frac{1}{2}$ W	1	EB-3905	01121	0686-3905	1
R98	fxd, comp 1KΩ ±5% $\frac{1}{2}$ W		EB-1025	01121	0686-1025	
R99	fxd, comp 360Ω ±5% $\frac{1}{2}$ W	1	EB-3615	01121	0686-3615	1
R100	fxd, comp 750Ω ±5% $\frac{1}{2}$ W		EB-7515	01121	0686-7515	
R101	fxd, comp 82Ω ±5% $\frac{1}{2}$ W	3	EB-8205	01121	0686-8205	1
R102	fxd, comp 470Ω ±5% $\frac{1}{2}$ W	1	EB-4715	01121	0686-4715	1
R103	fxd, comp 180Ω ±5% $\frac{1}{2}$ W	3	EB-1815	01121	0686-1815	1
R104	fxd, comp ~~200Ω~~ ±5% $\frac{1}{2}$ W 160Ω		EB-2015	01121	0686-~~2015~~ 1615	
R105	fxd, comp ~~27Ω~~ ±5% $\frac{1}{2}$ W 43Ω	2	EB-2705	01121	0686-~~2705~~ 4305	
R106	fxd, comp 82KΩ ±5% $\frac{1}{2}$ W	1	EB-8235	01121	0686-8235	1
R107	fxd, comp 68KΩ ±5% 1W	1	GB-6835	01121	0689-6835	1
R108	fxd, comp 200Ω ±5% $\frac{1}{2}$ W		EB-2015	01121	0686-2015	
R109	fxd, comp 82Ω ±5% $\frac{1}{2}$ W		EB-8205	01121	0686-8205	
R110	NOT ASSIGNED					
R111	fxd, comp 180Ω ±5% $\frac{1}{2}$ W		EB-1815	01121	0686-1815	
R112	fxd, comp ~~200Ω~~ ±5% $\frac{1}{2}$ W 160Ω		EB-2015	01121	0686-~~2015~~ 1615	
R113	fxd, comp ~~27Ω~~ ±5% $\frac{1}{2}$ W 43Ω		EB-2705	01121	0686-~~2705~~ 4305	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A7R114	fxd, ww 2.7Ω ±5% 2W	2	Type BWH	07716	0811-1671	1
R115	fxd, met. oxide 47KΩ ±5% 2W	5	Type C42S	16299	0764-0031	1
R116	fxd, met. oxide 27KΩ ±5% 2W	2	Type C42S	16299	0764-0007	1
R117	fxd, met. oxide 22KΩ ±5% 2W	3	Type C42S	16299	0764-0045	1
R118	fxd, met. oxide 47KΩ ±5% 2W		Type C42S	16299	0764-0031	
R119	fxd, comp 200Ω ±5% $\frac{1}{2}$ W		EB-2015	01121	0686-2015	
R120	NOT ASSIGNED					
R121	fxd, comp 82Ω ±5% $\frac{1}{2}$ W		EB-8205	01121	0686-8205	
R122	fxd, comp 160KΩ ±5% $\frac{1}{2}$ W	1	EB-1645	01121	0686-1645	1
R123	fxd, met. oxide 47KΩ ±5% 2W		Type C42S	16299	0764-0031	
R124	fxd, comp 180Ω ±5% $\frac{1}{2}$ W		EB-1815	01121	0686-1815	
R125	fxd, ww 2.7Ω ±5% 2W		Type BWH	07716	0811-1671	
R126	fxd, met. oxide 22KΩ ±5% 2W		Type C42S	16299	0764-0045	
R127,128	fxd, met. oxide 47KΩ ±5% 2W		Type C42S	16299	0764-0031	
R129	fxd, met. oxide 27KΩ ±5% 2W		Type C42S	16299	0764-0007	
R130	fxd, met. oxide 22KΩ ±5% 2W		Type C42S	16299	0764-0045	
R131	fxd, comp 20K ±5% 1/2W	1	EB-2035	01121	0686-2035	1
T1	Toroidal Transformer 1:1:1	1		28480	9100-2185	1
VR1,2	Diode, Zener 12.4V 400mW	2		28480	1902-3185	2
VR3,4	Diode, Zener 56.2V 1W	4		28480	1902-0597	4
VR5,6	Diode, Zener 9.4V 500mW	2	~~1N2163A~~	04713	1902-~~0763~~	07285
VR7	Diode, Zener 7.5V 400mW	1		28480	1902-0064	1
VR8,9	Diode, Zener 56.2V 1W			28480	1902-0597	
VR10	Diode, Zener 16.2V 400mW	1		28480	1902-0184	1
VR11	Diode, Zener 20.5V 400mW	1		28480	1902-0182	1
VR12,13	Diode, Zener ~~6.8V~~ 6.65V 400mW	2		28480	1902-~~0048~~ 3122	2
	CHASSIS ELECTRICAL PARTS					
C1,2	fxd, elect. 5,600μF 25Vdc	2		28480	0180-1921	1
C3	fxd, elect. 8,600μF 25Vdc	1		28480	0180-2385	1
C4,5	NOT ASSIGNED					
C6,7	fxd, elect. 430μF 200V	2		28480	0180-1808	1
C8	fxd, mylar 0.01μF 200Vdc	1	192P10392	56289	0160-0161	1
DS1	Lamp, glow 115V	1	NE-2H	03508	2140-0015	1
F1	Fuse, 2A 250V, T.	1	MDX-2A	71400	2110-0303	5
J1	Jack, input	1		28480	1251-0087	1
M1	Voltmeter	1		28480	1120-1154	1
M2	Ammeter	1		28480	1120-1155	1
P1	Plug, Input	1		28480	1251-0086	1
Q1-6	Power NPN Si.	6		28480	1854-0463	6
S1	Switch, AC Line	1	110-72	73559	3101-1055	1
S2	Switch, Range, Current	1	212-18699-1	11236	3100-1916	1
S3	Switch, Range, Voltage	1	212-7966-1	11236	3100-1919	1
T3	Power Transformer	1		28480	06131-80091	1
Z1	+5V Regulator, IC	1	SL10236	27014	1820-0430	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	MECHANICAL					
	A1 Input Board					
	Card Extractor Handle	1		28480	5081-4901	
	Roll Pin	1	52012062-250	72962	1480-0059	1
	A2 Logic Board					
	Card Extractor Handle	1		28480	5081-4902	
	Roll Pin	1	52012062-250	72962	1480-0059	1
	IC Socket, 16-pin(Z1A1-A4 or Z7A1-A4)	8	316-AG5D-3R	91506	1200-0767	1
	IC Socket, 14-pin(Z1-Z4, and Z2A1-A4 through A6A1-A4)	24	314-AG5D-3R	91506	1200-0768	1
	A3 D/A Board					
	Card Extractor Handle	1		28480	5081-4904	
	Roll Pin	1	52012062-250	72962	1480-0059	1
	Heat Dissipator, Q31	1	NF-207	05820	1205-0033	1
	A6 Control Board					
	Card Extractor Handle	1		28480	5081-4906	
	Roll Pin	1	52012062-250	72962	1480-0059	1
	Heat Dissipator (Q34)	1	NF-207	05820	1205-0033	1
	A7 Amplifier Board					
	Card Extractor Handle	1		28480	06131-80001	
	Roll Pin	1	52012062-250	72962	1480-0059	1
	Heat Dissipator (Q6,7,11,13,15 17,26,28,31,33)	10	NF-207	05820	1205-0033	1
	Front Panel Assembly					
	Front Panel (loaded)	1		28480	06131-60009	
	Front Panel (lettering)	1		28480	06131-60008	
	Meter Bezel	2		28480	4040-0297	1
	Meter Spring	8		28480	1460-0256	2
	Base, Indicator DS1	1		28480	5040-0305	1
	Lens, Indicator DS1	1		28480	5040-0234	1
	Knob, Black, Pointer	2		28480	0370-1099	1
	Front Door Assembly	1		28480	06130-60009	
	Door, Blank (Lettering Only)	1		28480	06130-00012	
	Spring, Door	1		28480	06130-00011	1
	Lens, Door	1		28480	5040-0234	1
	Latch, Door	1	27-10-301-10	94222	1390-0037	1
	Rear Panel Assembly	1		28480	5060-7992	
	Rear Panel	1		28480	5000-9490	
	Barrier Strip, 10-Terminal	1		75382	0360-1156	1
	Jumper, Barrier Strip	3		28480	0360-1143	1
	Heat Sink, Rear	2		28480	5020-8068	
	Cover, Heat Sink	2		28480	5000-9442	
	Spacer, Heat Sink Cover, Hex, 8-32 x 5/8 long	4		28480	0380-0719	
	AC Line Cord	1		28480	8120-0050	1
	Strain Relief Bushing, Line Cord	1		28480	0400-0013	1
	Shoulder Washer, Gray, Q1-Q6, Mounting Screws	12		28480	2190-0491	7
	Bushing, Transistor Pins, Q1-Q6	12		28480	0340-0166	7

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	Bushing, Transistor Screws, Q1-Q6	12		28480	0340-0168	7
	Insulator, Mica, Q1-Q6	6		28480	0340-0174	6
	Hinge, Plastic	2		28480	5040-1449	
	Bracket, Hinge	2		28480	5000-6208	
	Fuse Holder	1	342.014	75915	1400-0084	1
	Hex. Nut, Fuse Holder	1		28480	2950-0038	1
	Lockwasher, Fuse Holder	1		28480	2190-0037	1
	Neoprene Washer, Fuse Holder	1		28480	1400-0090	1
	Rear Chassis	1		28480	5000-6206	
	Spacer, Rear Chassis, Hex 8-32 x 7/8 long	4		28480	0380-0392	
	Cover, Bottom	1		28480	5000-9805	
	Cover, Top	1		28480	5000-9806	
	Side Frame	2		28480	5060-0731	
	Side Cover, Front	2		28480	5000-8703	
	Side Cover, Rear	2		28480	5000-8701	
	Side Trim, Fluted, Adhesive Back	2		28480	5000-0051	
	Handle Assembly, Side	2		28480	5060-0222	1
	Retainer, Side Handle, Sheet Metal	2		28480	5060-0766	1
	Chassis, Power Supply, U-Shape, Aluminum Sheet Metal	1		28480	5000-6205	
	Chassis, Plug-In Card, Aluminum Sheet Metal	1		28480	5000-6204	
	Guide Rail, Plug-In Card, Plastic, Right	5		28480	5040-1419	
	Guide Rail, Plug-In Card, Plastic, Left	5		28480	5040-1420	
	Shoulder Washer, Plug-In Card Chassis	8		28480	2190-0492	
	Spacer, P.C. Guide 3/8" O.D., #10 C.L.	12	9319-A-194	06540	0380-0471	
	Clamp Tube, C1, C2	2		28480	5000-6276	
	MISCELLANEOUS					
	Clamp, 1/4" Dia.	3	T4-4	79307	1400-0330	1
	Clamp, 2" Dia., C3	1	4586-2B	56289	0180-0078	1
	Clamp, 1-3/8" Dia., C6, C7	2	4586-97A	56289	0160-2149	1
	Foot Assembly	5		28480	5060-0767	1
	Stand, Tilt	1		28480	1490-0030	1
	Fastener	4	C17859632-24D	89032	0590-0053	1
	Fastener	9	C8022632-24B	89032	0590-0710	2
	Rack Mounting Kit (Includes Rack Ears, Trim, and Screws)	1		28480	5060-8740	
	Packing Carton	1		28480	9211-1180	
	Floater Pad, Packing Carton	2		28480	9220-1400	
	Extender Assembly, Plug-In Board	1		28480	5060-7948	
	Printed Circuit Board	1		28480	5020-8049	
	Printed Circuit Board Connector	1	251-20-30-390	71785	1251-0495	
	Epoxy Plate	1		28480	5020-5728	

SECTION VII
CIRCUIT DIAGRAMS

7-1 INTRODUCTION

7-2 This section contains the circuit diagrams necessary for the operation and maintenance of Model 6131C Digital Voltage Source.

7-3 OVERALL BLOCK DIAGRAM

7-4 This diagram, Figure 7-1, shows the relationship between the instrument assemblies and ties the schematic diagrams together. A timing diagram is provided in Figure 7-1 to aid in the understanding of the operation of the instrument.

7-5 COMPONENT LOCATION ILLUSTRATIONS

7-6 The component location diagrams show the physical location of parts mounted on each assembly. They are included on the schematic diagrams where they apply or on the rear of the previous schematic. Thus, the schematic diagram is unfolded to the right and component location diagram is unfolded to the left.

7-7 SCHEMATIC DIAGRAMS

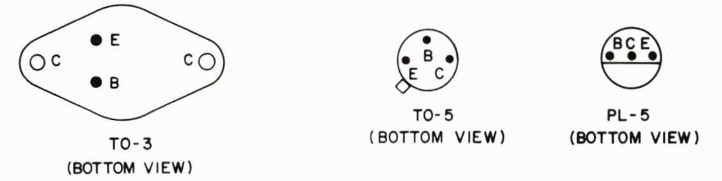
7-8 The circuits are functionally separated and included on a series of schematic diagrams, Figure 7-2, Sheets 1 through 4. Voltage Processing Circuits are contained on Sheet 1. The Current Latch Circuits are contained on Sheet 2. The signals from Sheets 1 and 2 are connected to the Power Amplifier, Sheet 3.

7-9 The Power Distribution Schematic Diagram, Figure 7-2, Sheet 4, illustrates the input ac, dc power supplies, and the distribution of dc voltages throughout the unit.

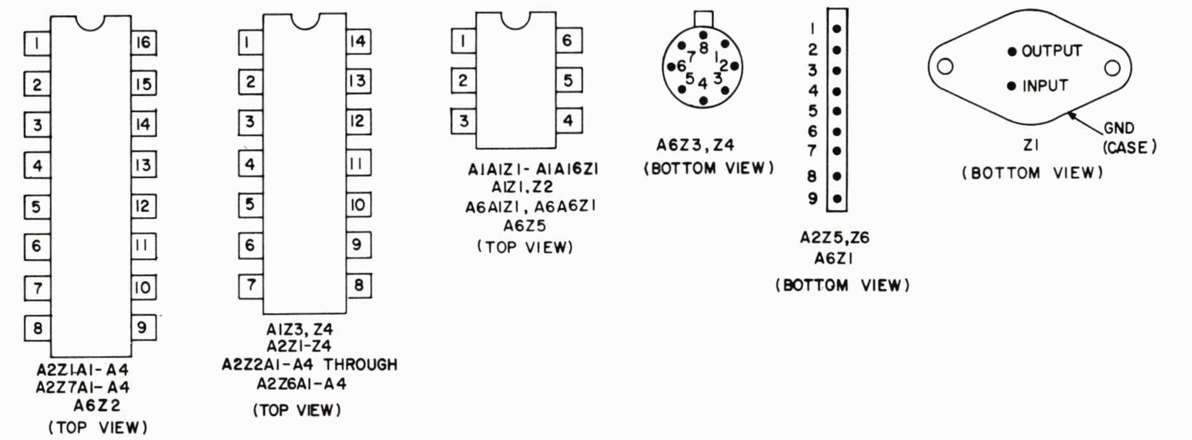
7-10 Test points (encircled numbers) appear throughout the schematics. These points coincide with the test points on the component locations diagrams and are referred to throughout the text.

NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/2W, 5%, UNLESS OTHERWISE INDICATED.
2. ALL 1/4W AND 1/8W RESISTORS ARE 1%, UNLESS OTHERWISE INDICATED.
3. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
4. [box] DENOTES FRONT PANEL MARKING.
5. [dashed box] DENOTES REAR PANEL MARKING.
6. * DENOTES CHASSIS-MOUNTED COMPONENT.
7. DENOTES VOLTAGE FEEDBACK.
8. DENOTES CURRENT FEEDBACK.
9. PIN LOCATIONS FOR TRANSISTORS ARE AS FOLLOWS:

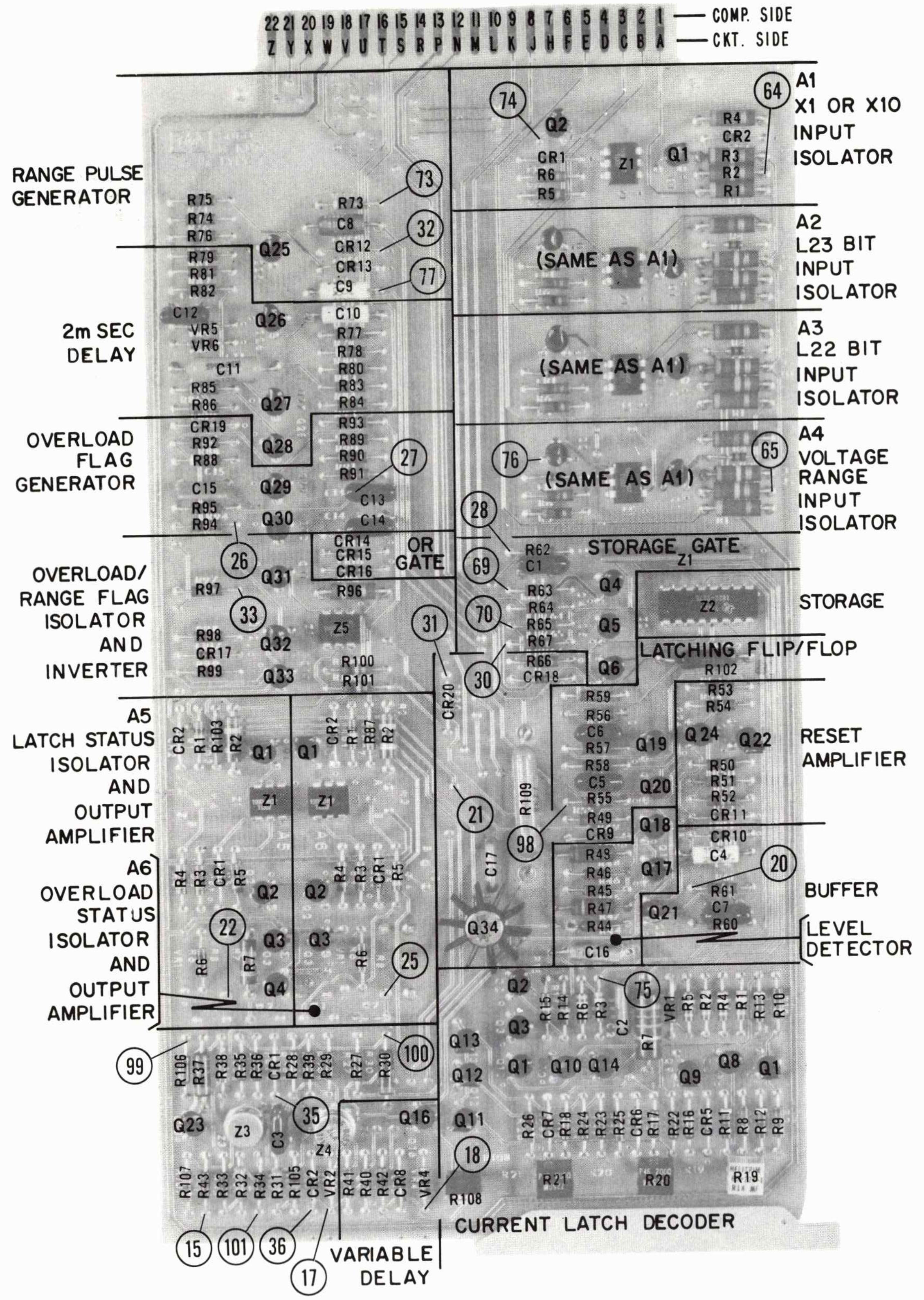


10. PIN LOCATIONS FOR INTEGRATED CIRCUITS ARE AS FOLLOWS:



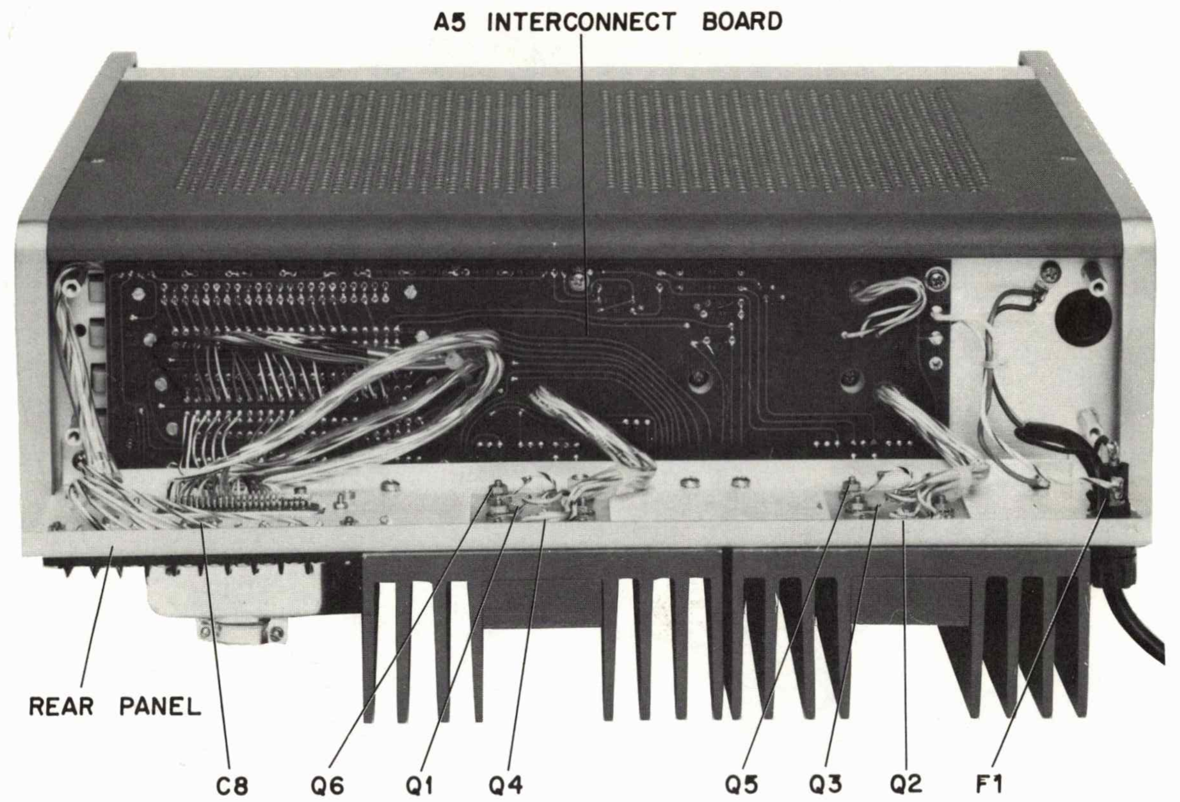
11. THE RESISTANCE VALUES OF BIAS RESISTORS R1-R3 DEPEND ON THE STANDARD OPTION OF THE INSTRUMENT OR WHETHER THE INSTRUMENT IS A SPECIAL MODIFICATION. REFER TO THE APPROPRIATE OPTION APPENDIX OR THE INSTRUMENT MODIFICATION SHEET FOR THIS INFORMATION.
12. THE FOLLOWING COMPONENTS MAY OR MAY NOT BE INCLUDED, DEPENDING ON WHICH STANDARD OPTION APPLIES OR WHETHER THE INSTRUMENT IS A SPECIAL MODIFICATION: A1Q6, A1R15, A1R17, A1R18, A1VR5, A6CR14, A6CR15, A6A5R8, A6A6R8, A6A5VR1, AND A6A6VR1. REFER TO THE APPROPRIATE OPTION APPENDIX OR THE INSTRUMENT MODIFICATION SHEET FOR INFORMATION ON THESE COMPONENTS, (A6CR14 AND A6CR15 ARE USED IN ALL STANDARD BCD INSTRUMENTS).
13. THESE JUMPERS ON THE A1 AND A6 BOARDS ARE POSITIONED AS SHOWN EXCEPT IN SPECIALLY-MODIFIED INSTRUMENTS. REFER TO THE INSTRUMENT MODIFICATION SHEET SUPPLIED WITH THE INSTRUMENT.
14. THE FOLLOWING COMPONENTS, DRAWN WITH DASHED LINES, ARE NOT INCLUDED EXCEPT IN SPECIALLY-MODIFIED INSTRUMENTS: A1Q1, A1Q7, A1R4, AND A1R19. REFER TO THE INSTRUMENT MODIFICATION SHEET SUPPLIED WITH THE MANUAL.
15. THE OUTPUT POLARITY OF THE FOUR STORAGE I.C. PACKAGES ON THE A2 BOARD DEPENDS ON WHETHER THEY ARE LOCATED IN THE Z1 OR THE Z7 SOCKETS. THE JUMPERS DRAWN AT THE OUTPUTS REPRESENT THIS CHOICE OF SOCKETS. THE APPROPRIATE OPTION APPENDIX IDENTIFIES WHICH ARE THE PROPER SOCKETS.
16. THE POSITION OF THESE TWO JUMPERS ON THE A2 BOARD DEPENDS ON THE STANDARD OPTION OF THE INSTRUMENT OR WHETHER THE INSTRUMENT IS A SPECIAL MODIFICATION. IN OPTION 061 INSTRUMENTS W1 AND W2 ARE BOTH CONNECTED TO B. IN OPTION 063 INSTRUMENTS, THEY ARE CONNECTED TO A. FOR SPECIALLY-MODIFIED INSTRUMENTS, REFER TO THE INSTRUMENT MODIFICATION SHEET FOR THIS INFORMATION.
17. FOR SPECIALLY-MODIFIED INSTRUMENTS, THE CIRCUIT CONFIGURATION OF OUTPUT AMPLIFIER STAGES A6A5Q3, A6A5Q4, A6A6Q3, AND A6A6Q4 MAY DIFFER FROM SCHEMATIC. NOTE THAT A6A6Q4 AND A6A6R7 ARE NOT INCLUDED IN ANY OF THE STANDARD OPTIONS. REFER TO THE INSTRUMENT MODIFICATION SHEET SUPPLIED WITH THE INSTRUMENT.

Figure 7-2 (Sheet 1). Voltage Processing, Schematic Diagram

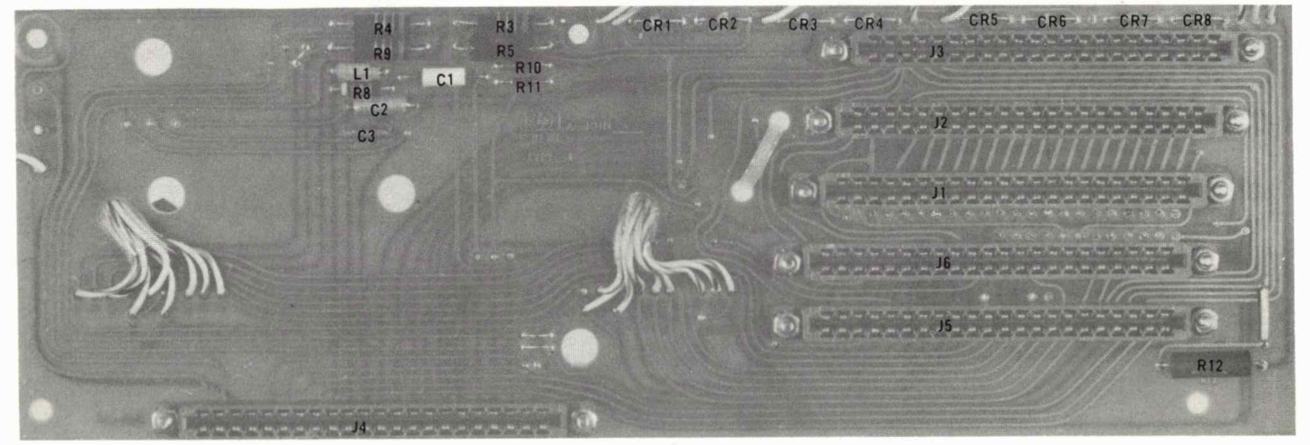


A6 Control Board, Component Location

Figure 7-2 (Sheet 2). Current Latch and Voltage Range Processing, Schematic Diagram

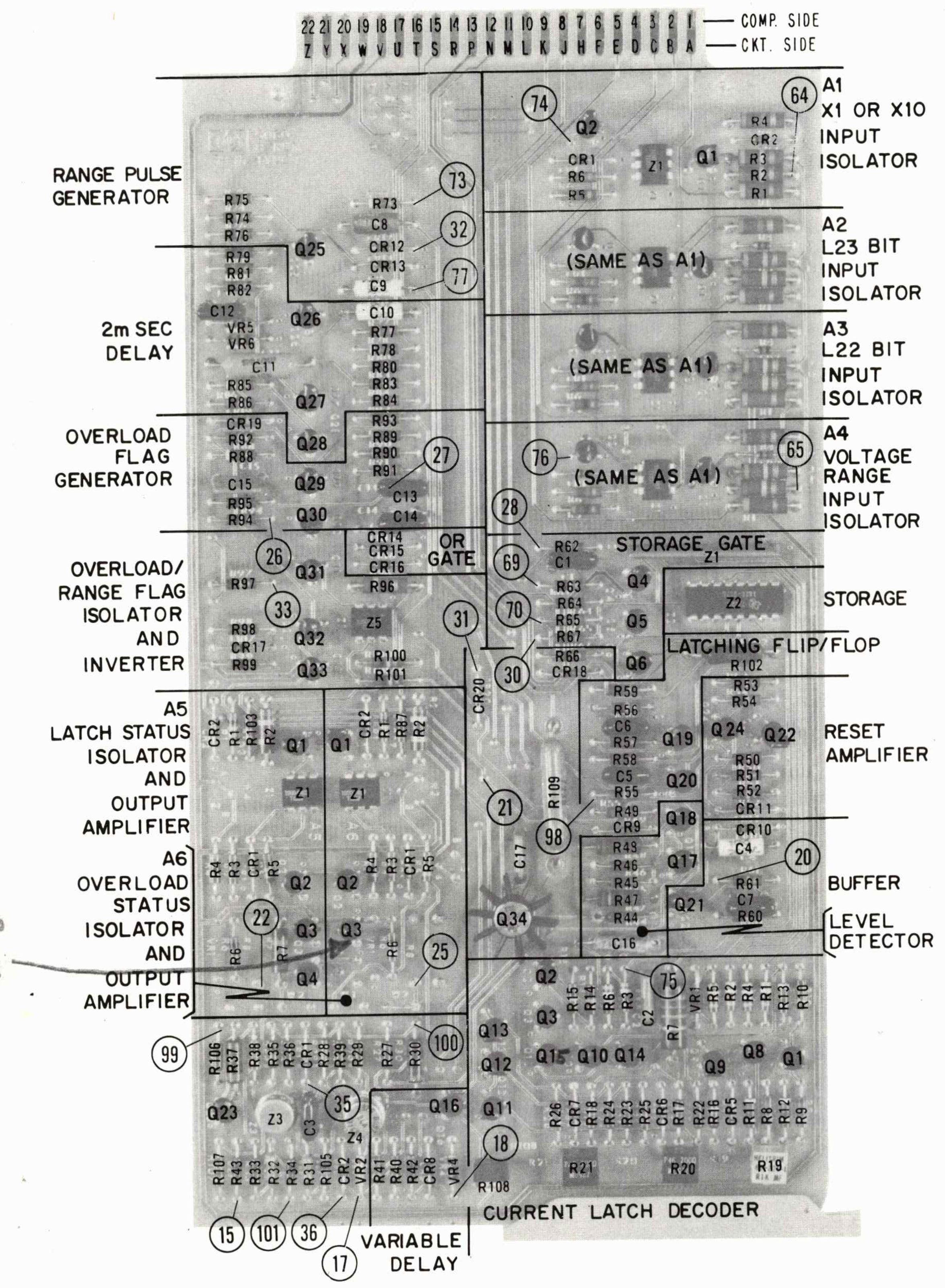


Rear View, Component Location



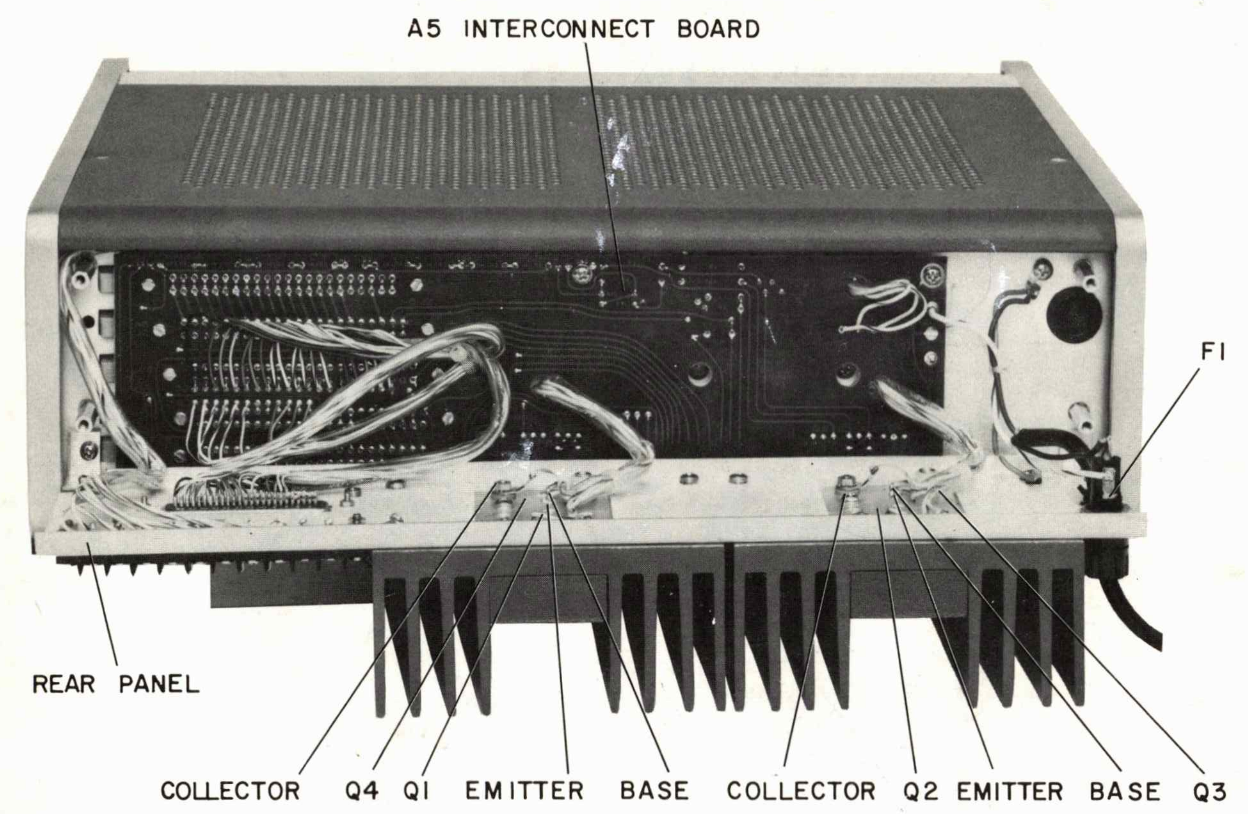
A5 Interconnect Board, Component Location

Q17 18 1854-0087
19 20 1853-0099
21 1854-0087

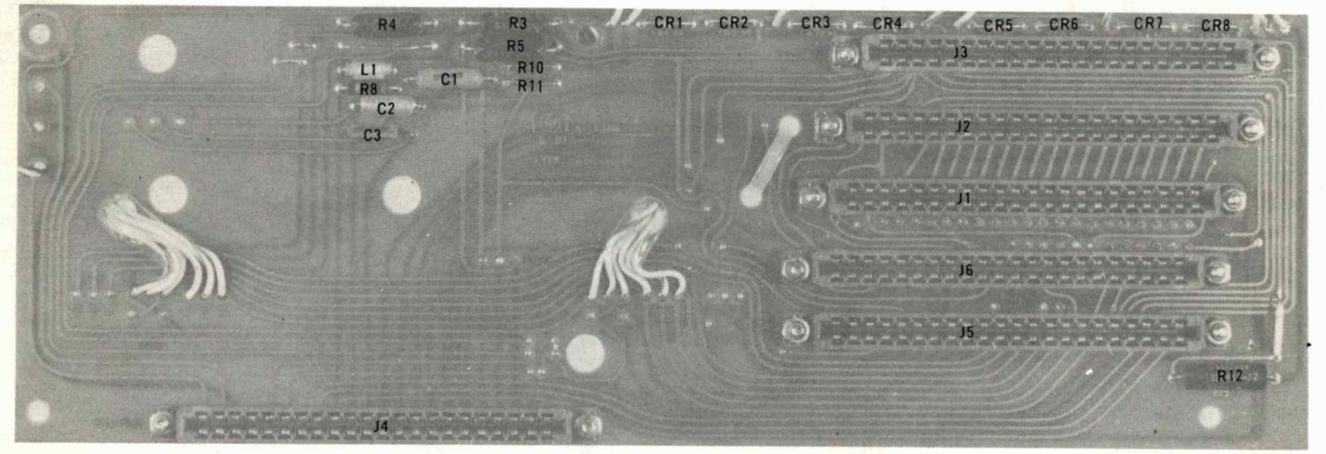


A6 Control Board, Component Location

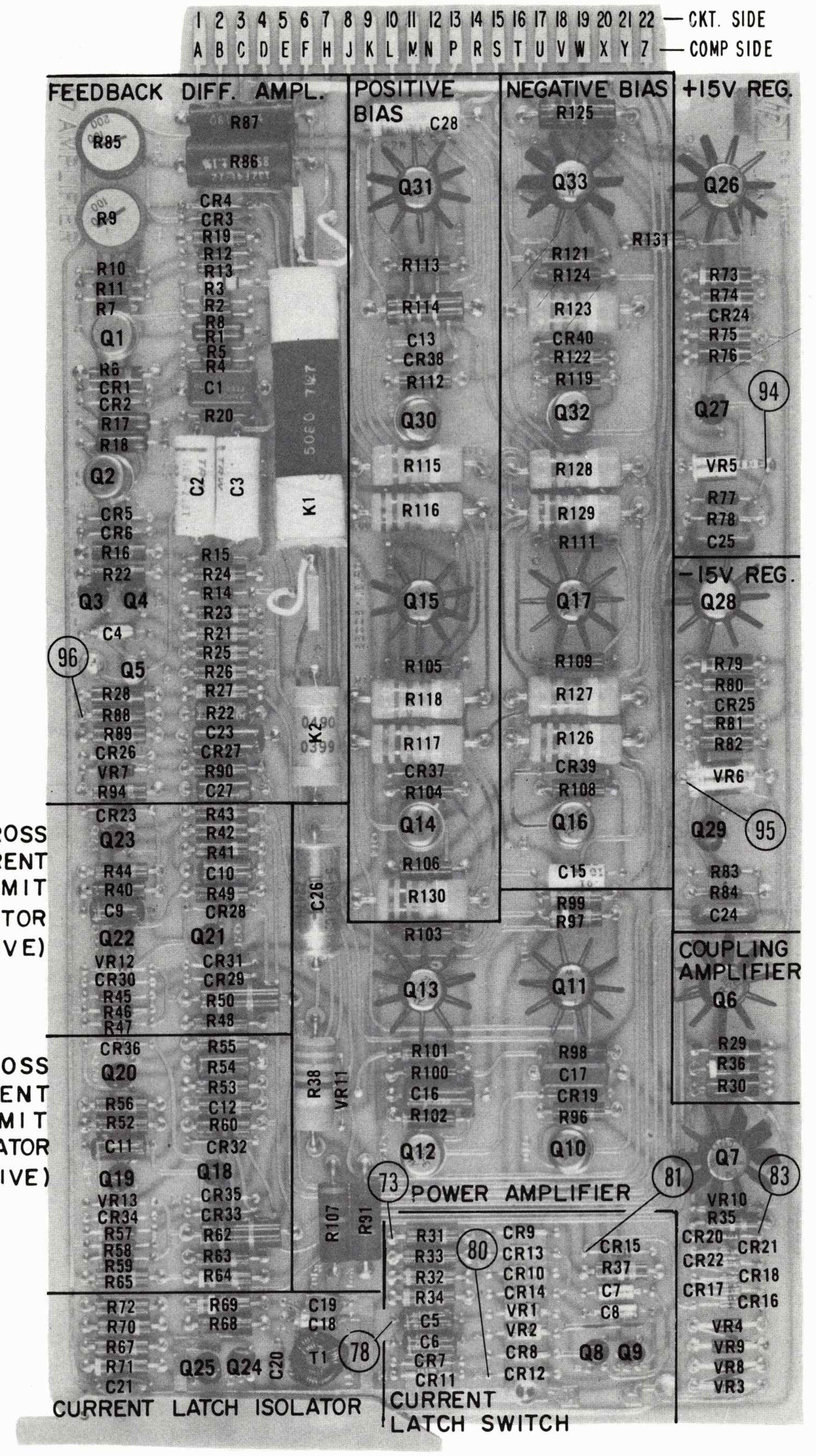
Figure 7-2 (Sheet 2). Current Latch and Voltage Range Processing, Schematic Diagram



Rear View, Component Location



A5 Interconnect Board, Component Location

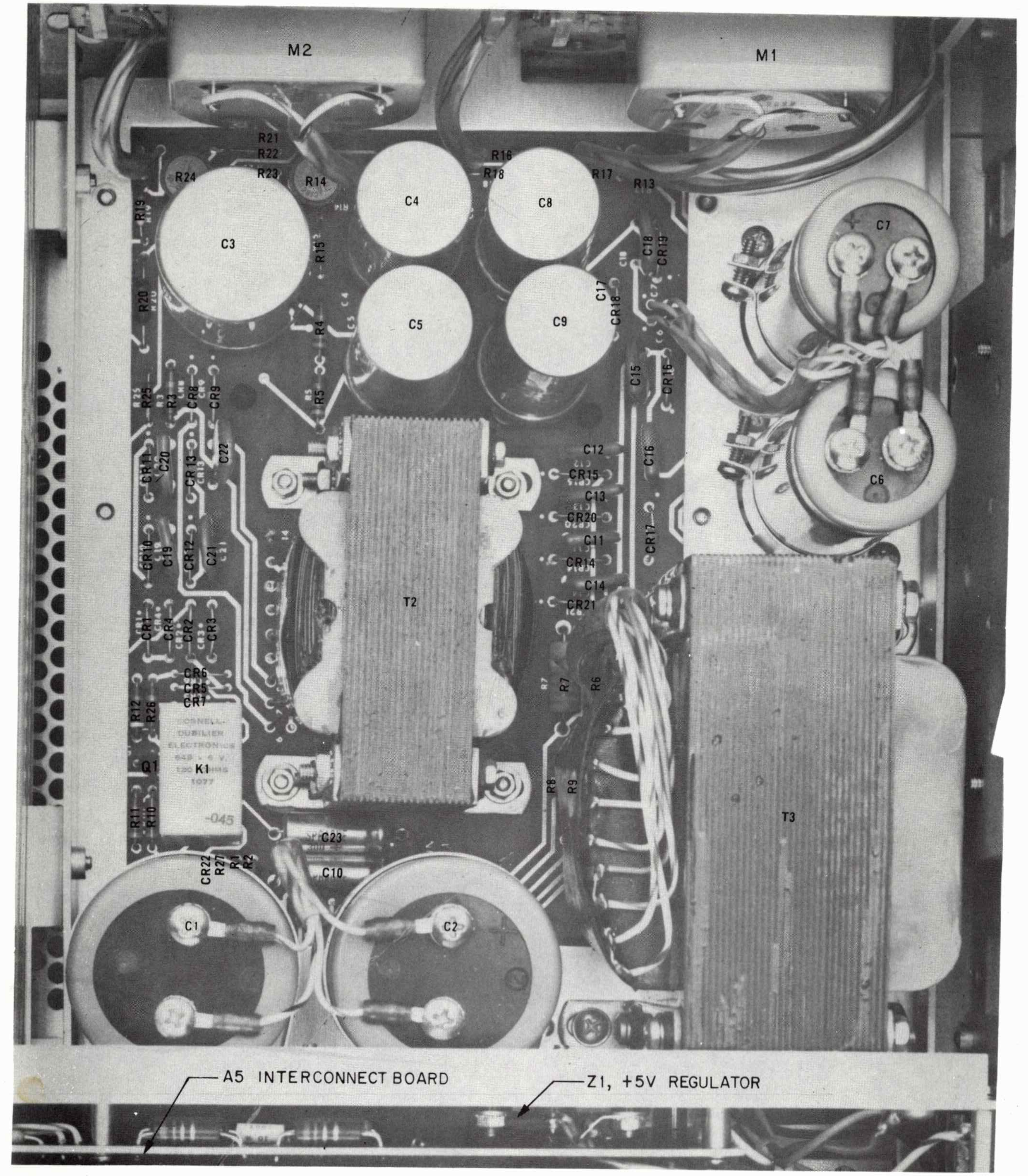


A7 Amplifier Board, Component Location

6131C

Figure 7-2 (Sheet 3). Power Amplifier, Schematic Diagram

Figure 7-2 (Sheet 3). Power Amplifier, Schematic Diagram



A4 Power Supply Board, Component Location

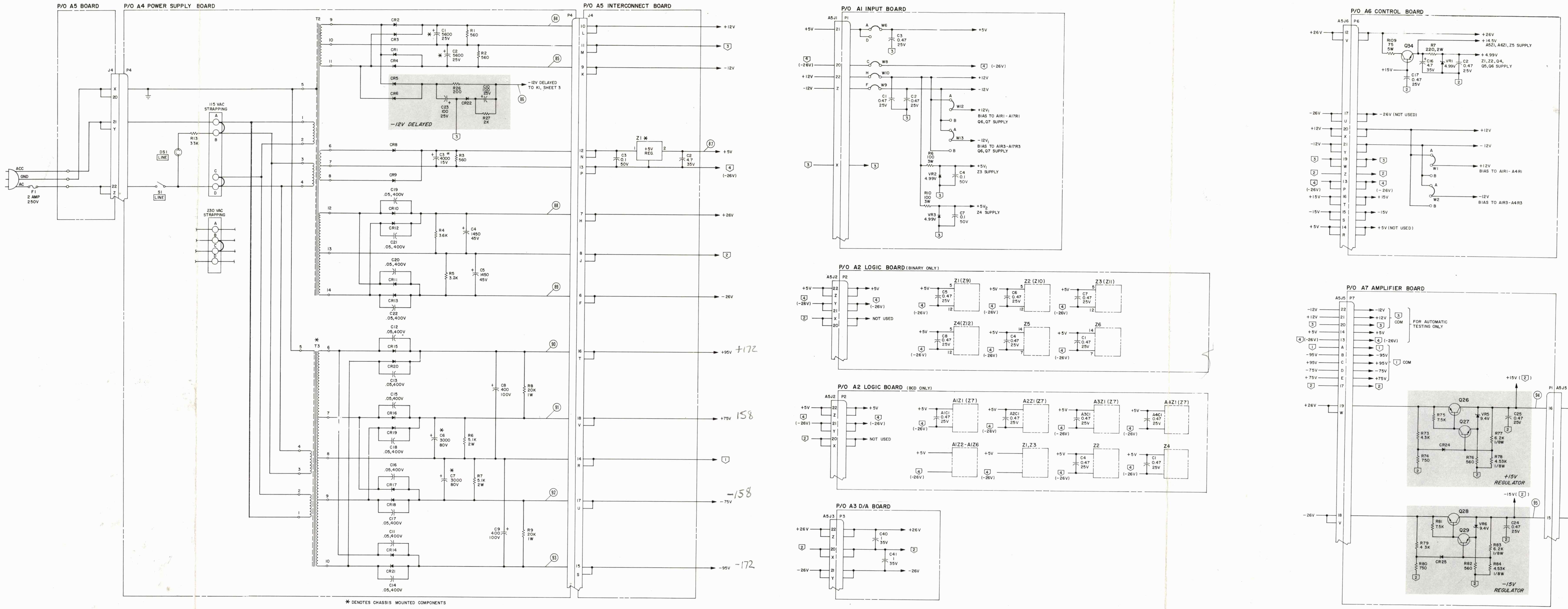
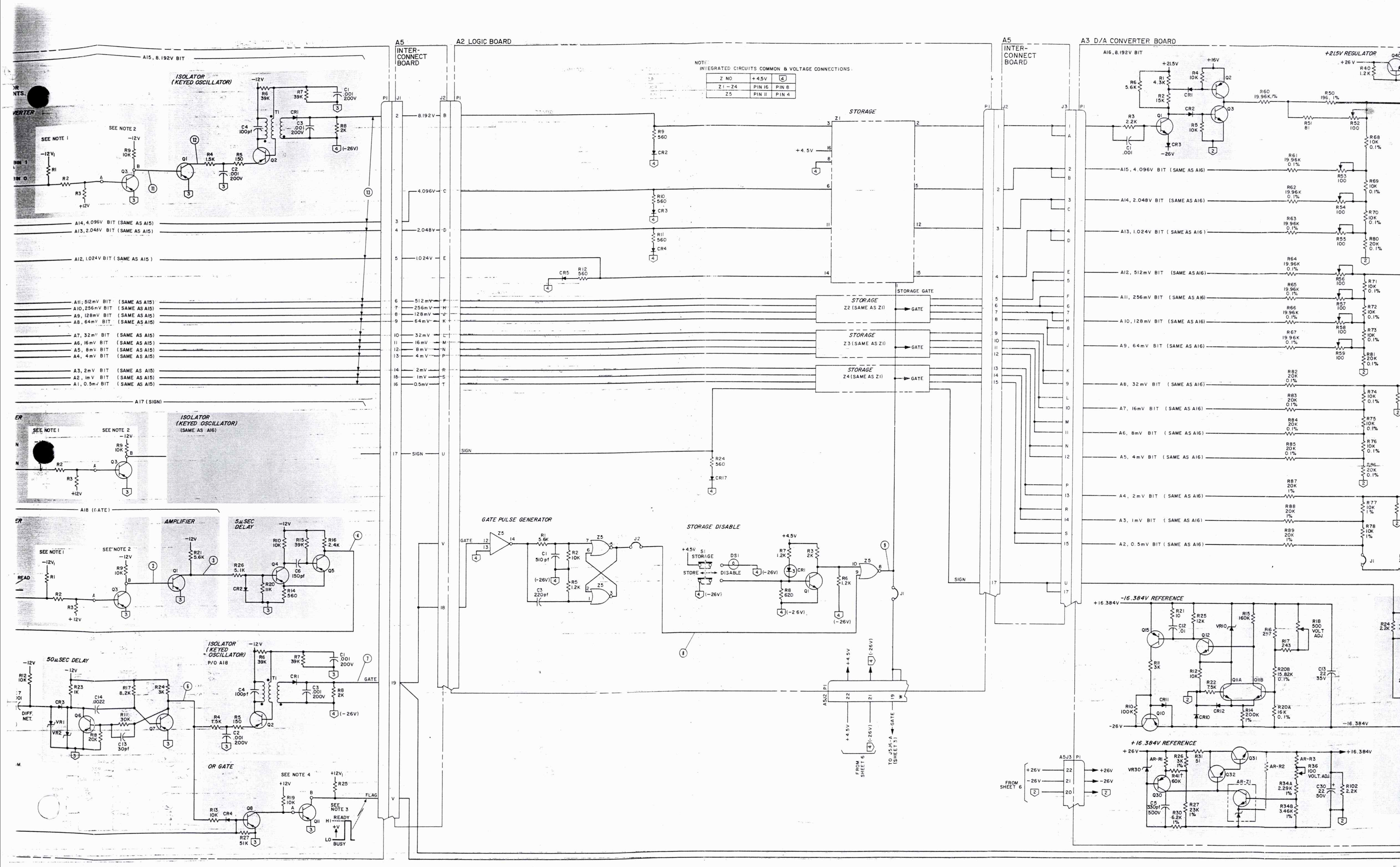
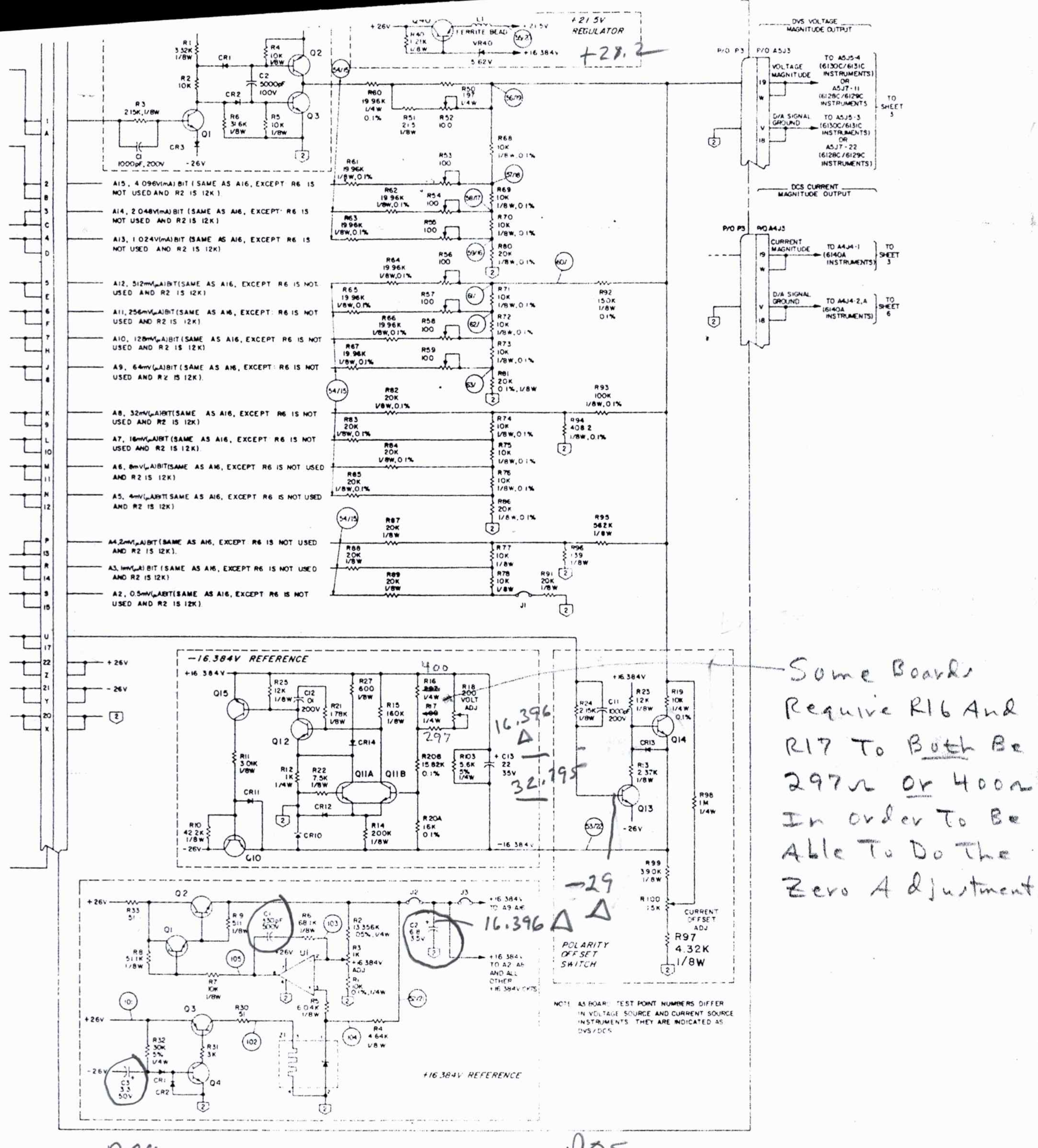


Figure 7-2 (Sheet 4). Power Distribution Schematic Diagram



A5 INTER-CONNECT BOARD
A2 LOGIC BOARD
A5 INTER-CONNECT BOARD
A3 D/A CONVERTER BOARD
NOTE: INTEGRATED CIRCUITS COMMON & VOLTAGE CONNECTIONS
Z NO | +4.5V | 4
Z1 - Z4 | PIN 16 | PIN 8
Z5 | PIN 11 | PIN 4
A15, 8.192V BIT
ISOLATOR (KEYED OSCILLATOR)
SEE NOTE 1
SEE NOTE 2
A14, 4.096V BIT (SAME AS A15)
A13, 2.048V BIT (SAME AS A15)
A12, 1.024V BIT (SAME AS A15)
A11, 512mV BIT (SAME AS A15)
A10, 256mV BIT (SAME AS A15)
A9, 128mV BIT (SAME AS A15)
A8, 64mV BIT (SAME AS A15)
A7, 32mV BIT (SAME AS A15)
A6, 16mV BIT (SAME AS A15)
A5, 8mV BIT (SAME AS A15)
A4, 4mV BIT (SAME AS A15)
A3, 2mV BIT (SAME AS A15)
A2, 1mV BIT (SAME AS A15)
A1, 0.5mV BIT (SAME AS A15)
A17 (SIGN)
ISOLATOR (KEYED OSCILLATOR) (SAME AS A16)
A18 (GATE)
AMPLIFIER
5µSEC DELAY
50µSEC DELAY
ISOLATOR (KEYED OSCILLATOR) P/O A18
OR GATE
SEE NOTE 3
SEE NOTE 4
READY
BUSY
FLAG
GATE
DIFF. NET.
STORAGE
STORAGE Z2 (SAME AS Z1)
STORAGE Z3 (SAME AS Z1)
STORAGE Z4 (SAME AS Z1)
STORAGE GATE
SIGN
GATE PULSE GENERATOR
STORAGE DISABLE
STORE
DISABLE
FROM SHEET 6
TO J5/J6-A (SHEET 3)
A16, 8.192V BIT
+21.5V REGULATOR
A15, 4.096V BIT (SAME AS A16)
A14, 2.048V BIT (SAME AS A16)
A13, 1.024V BIT (SAME AS A16)
A12, 512mV BIT (SAME AS A16)
A11, 256mV BIT (SAME AS A16)
A10, 128mV BIT (SAME AS A16)
A9, 64mV BIT (SAME AS A16)
A8, 32mV BIT (SAME AS A16)
A7, 16mV BIT (SAME AS A16)
A6, 8mV BIT (SAME AS A16)
A5, 4mV BIT (SAME AS A16)
A4, 2mV BIT (SAME AS A16)
A3, 1mV BIT (SAME AS A16)
A2, 0.5mV BIT (SAME AS A16)
-16.384V REFERENCE
+16.384V REFERENCE
R18 500 VOLT ADJ
R36 100 VOLT. ADJ
FROM SHEET 6



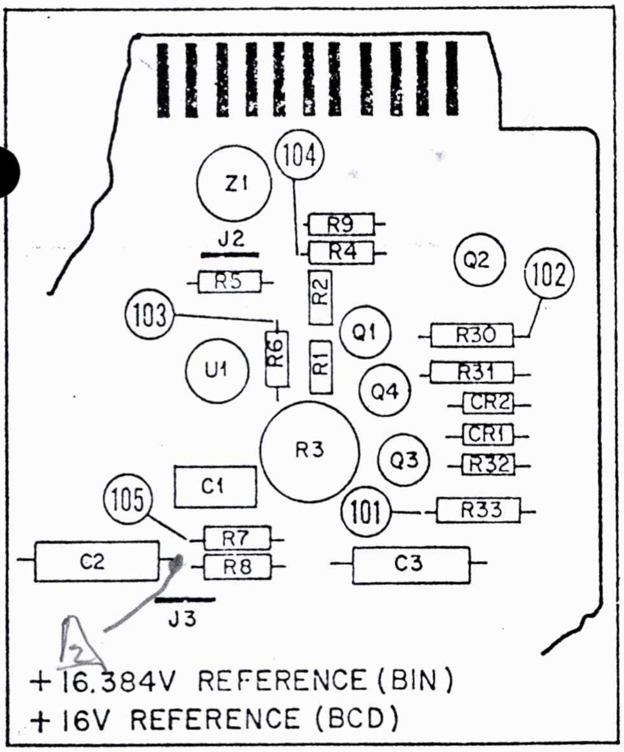
Some Boards Require R16 And R17 To Both Be 297Ω or 400Ω In order To Be Able To Do The Zero Adjustment.

neg
Q13B -29.1
C -29.8

pos
Q13B -5A
C -15.63

Models: 6128C—Part of Change 3; 6129C—Part of Change 7; 6130C—Part of Change 5; 6131C, 6140A—Part of Change 6.

CRBC -17.04 -15.63
Q14C -1.8MV -16.38



Part of Change 5

CHANGE 6:

To allow automatic IC insertion, 8 16-pin and 2 14-pin IC sockets have been eliminated from the A2 Logic Board. Make this correction on page 6-15 of the parts list. (Some units with later serial numbers may include IC sockets on the A2 Board.)

CHANGE 7:

Delete capacitor A3C41 from the attached A3 Board parts list and from the Figure 7-2, Sheet 4 schematic. Add a new 2200pF 200V capacitor, A3C42, (HP Part No. 0160-2289) to the same schematic and to the attached parts list. C42 is connected between pins 20 and 21 on the board near its edge connector. (This change also applies to earlier instruments with the following serial numbers: 1633A-00656, -00664, -00667, -00668, -00669.)

ERRATA:

On the attached parts list for the A3 Board, change the HP Part No. for A3R52 through A3R59 to 2100-1770. The resistors have not been changed; just their part number has.

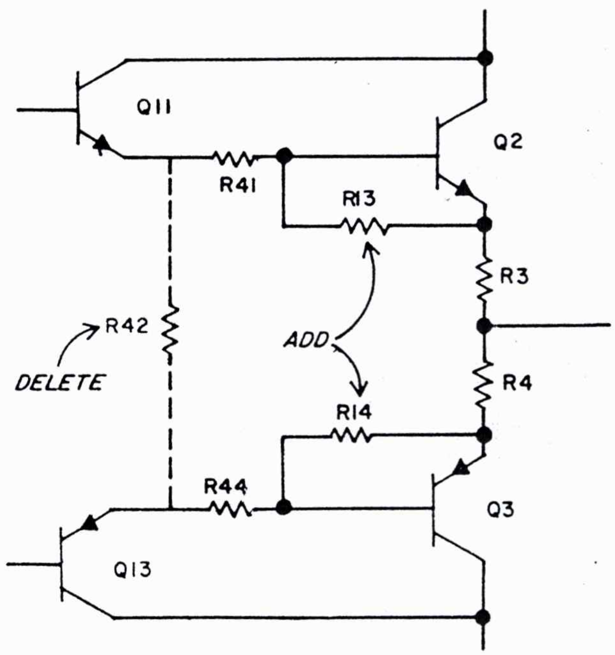
On page 6-8 of the parts list, change the HP Part No. of A4R14 to 2100-1775; and on page 6-13, change A7R9 to 2100-1770. These resistors have not been changed; just their part numbers have.

In the A7 Board component location diagram [illegible] 3 of Figure 7-2, change CR36 (in the right-hand column) in the negative gross current limit comparator to CR37.

On page 6-12 the part number for A6Z4 is incorrect; change it to 1826-0092. Also add A6Z5 to the parts list, A6Z5 is a photoisolator, HP Part No. 1990-0593.

CHANGE 8:

Make the following changes to Sheet 3 of the Figure 7-2 schematic and to the parts list. Delete resistor A7R42, 1kΩ, 5%, 1/2W, HP Part No. 0686-1025 from the A7 Amplifier Board. Add resistors A5R13 and A5R14 to the A5 Interconnect Board. Both are 100Ω, 5%, 1/2W, HP Part No. 0686-1015. R13 is connected between the base and emitter of output transistor Q2, and R14 between the base and emitter of Q3.



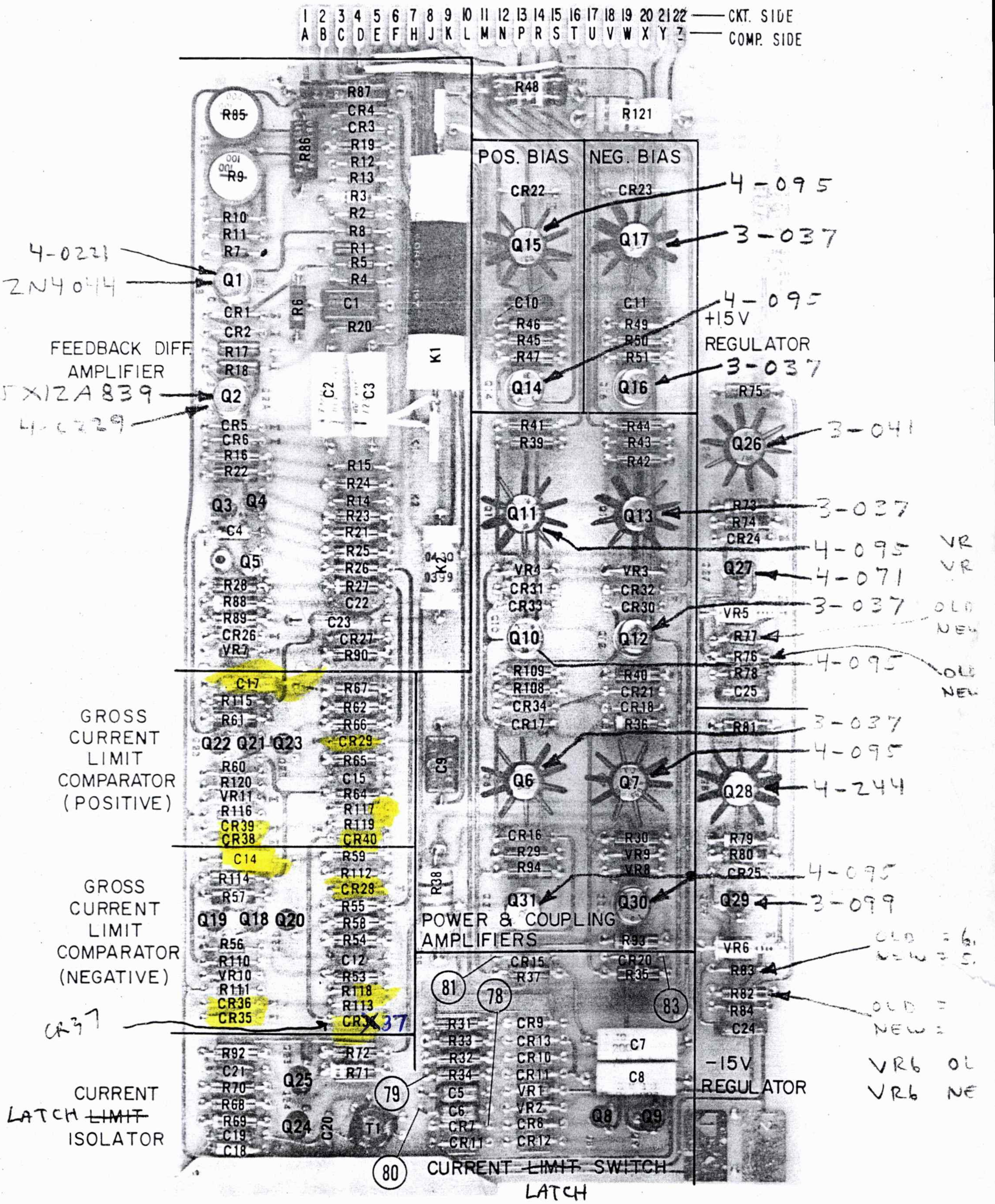
CHANGE 9:

Change relay A4K1 to 6V, 130Ω coil, H.P.Part No. 0490-0623.
Change resistor A4R26 to 240Ω, 5%, ½W, H.P.Part No. 0686-2415.

CHANGE 10

Change zener diodes A7VR5 and A7VR6 to 9V, HP Part No. 1902-0785. Change resistors A7R76 and A7R82 to 820Ω, 1/2W, HP Part No. 0686-8215. Change resistors A7R77 and A7R83 to 5.62KΩ, 1/8W, HP Part No. 0757-0200.

Note that the above changed parts (A4VR6, VR7, etc.) are not interchangeable in units with earlier prefix numbers (before 1835A) unless the zener diode and associated resistors (see schematic, Fig. 7-2 Sheet 4) are changed simultaneously.



A7 Amplifier Board, Component Location

APPENDIX A
OPTION 061-BCD Interface For Open Collector Circuits

A-1 INTRODUCTION

A-2 This Appendix describes the input and output data parameters for interfacing with a digital source employing "open collector" driver transistors. Only interfacing requirements are discussed in this Appendix. Information of a more general nature is given in Section III of this manual. Hence, for a complete conception of the operating and interfacing requirements, both this Appendix and Section III must be consulted.

A-3 The data parameters described in the following paragraphs include the following:

(1) BCD voltage magnitude data.
(2) Input/Output signal polarity.
(3) Logic coding - significance of high and low input/output signal states.
(4) Logic levels - voltage limits for high and low digital signal states.

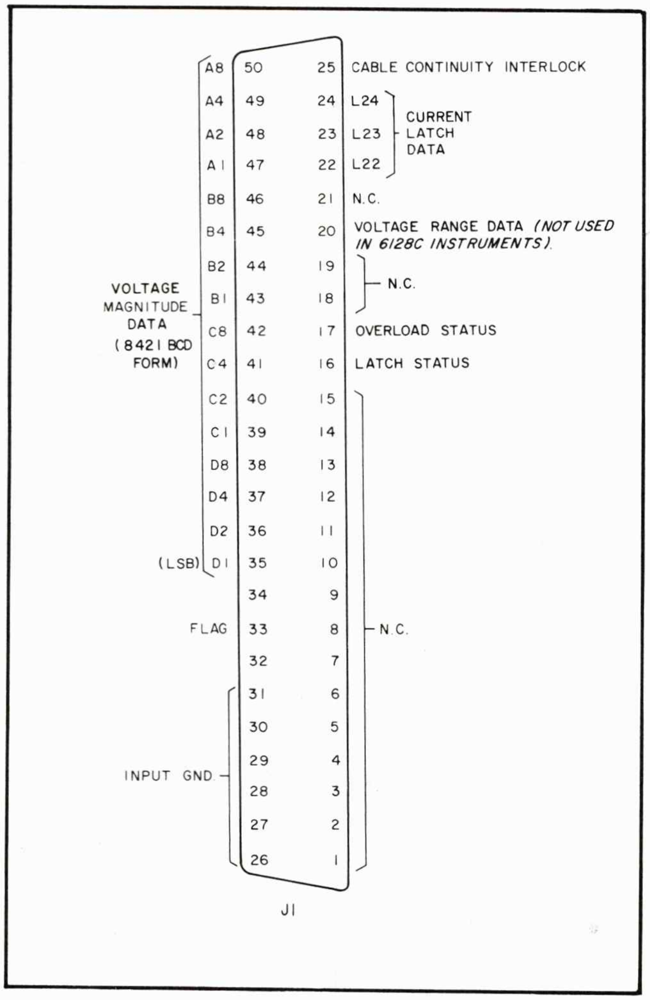


Figure A-1. Input/Output Data Connector

A-4 The digital input/output stages on three of the DVS plug-in boards (A1, A2, and A6) have been especially designed to obtain the desired data parameters under worse case conditions. A list of these special parts is included at the rear of this Appendix.

A-5 DATA CONNECTOR

A-6 Input/Output data is connected to the digital programming source by means of the rear connector (Figure A-1). The parameters associated with each of the signals of Figure A-1 are discussed in the following paragraphs.

A-7 INPUT/OUTPUT SIGNAL POLARITY

A-8 All input/output signals are of positive polarity (above 0 volts).

A-9 RECEIVER CIRCUITS AND LOGIC LEVELS

A-10 Figure A-2 shows an input circuit that applies to all of the digital inputs. The three resistors of the input voltage divider are selected so that a high input level will turn on the succeeding driver stage and a low input level will

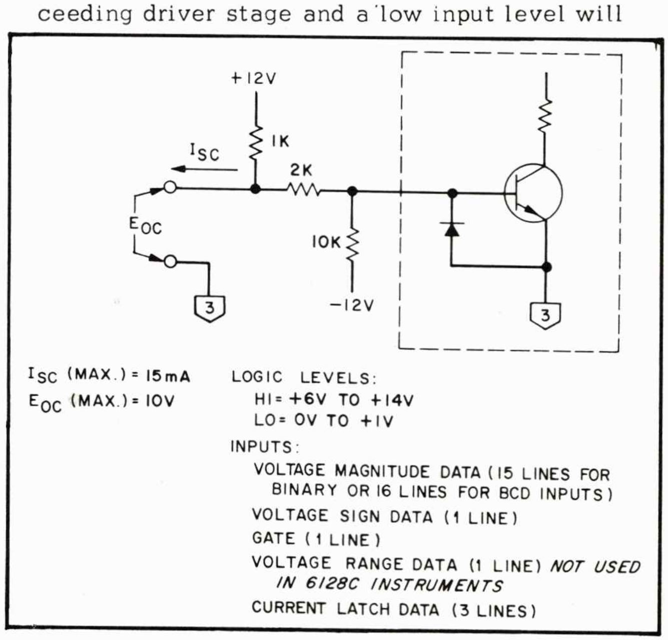


Figure A-2. Receiver Circuit

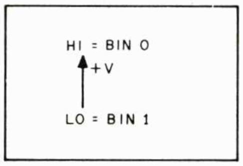
cut the stage off. As shown on Figure A-2, the logic levels for all of the listed inputs are high = + 6V to + 14V and low = 0V to + 1V.

A-11 The maximum current that can be drawn from the input circuit when the input terminals are short circuited is 15mA (designated I_{SC-MAX} on Figure A-2). The maximum voltage that can appear across the input terminals under open circuit conditions (designated E_{OC-MAX}) is 10V.

A-12 VOLTAGE MAGNITUDE INPUT DATA

A-13 Logic Type. The input data to this unit is received in 8-4-2-1 binary-coded decimal form on 16 input lines.

A-14 Logic Coding.



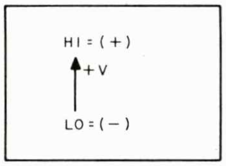
A-15 Logic Inversion. In order to provide the logic coding described above, the four storage IC's on the A2 board are located in the Z1 (rather than the Z7) sockets so they do not perform a signal inversion.

A-16 The 4 digit, (A through D), 16 bit voltage magnitude data is used in conjunction with the voltage range and voltage sign bits to control the output voltage of the DVS. The voltage sign input determines the polarity (+ or -) of the output voltage while the voltage range input multiplies the BCD voltage magnitude data by X1 or X10.

A-17 VOLTAGE SIGN

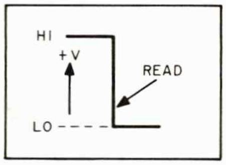
A-18 The voltage sign data bit determines the polarity of the output. Jumper connections A2W1-B and A2W2-B (Figure 7-2, sheet 1) are included for the coding shown below.

A-19 Logic Coding.



A-20 GATE

A-21 Logic Coding. As shown, a high to low transition of the gate input permits storage of the voltage magnitude voltage sign, current latch, and voltage range input data in the DVS storage registers. The STORAGE switch on the A2 P.C. Board (see Figure 3-2) must be in the STORE position to utilize this storage capability. Optional inverter stage A1Q1 is not used in this instrument.



A-22 VOLTAGE RANGE

A-23 Coding. HI = X10 (High voltage range)
LO = X1 (Low voltage range)

A-24 The following chart shows the coding required for voltage range.

INPUT CODE	VOLTAGE RANGE
Voltage Range Bit	
LO	X1
HI	X10

A-25 CURRENT LATCH

A-26 Coding. The current latch data forms a 3-bit binary code. The input codes for each current latch value are shown in the chart on page 3-5. Notice that the three current latch bits provide a maximum of six possible combinations.

A-27 C_T Terminals. As described in Section III, the current latch delay period is determined by the condition of the C_T terminals at the rear of the unit. Notice that if the C_T terminals are shorted, the DVS will not current latch even if the output current exceeds the programmed current latch value.

A-28 CABLE CONTINUITY INTERLOCK

A-29 Before output voltage can be obtained from the DVS, a connection must be made between input common (3) and the cable continuity interlock pin 25 of the input/output connector. If this connection is not made the output terminals of the DVS will be shorted by an internal relay. This protects the load device against excessive voltages in case the input cable is disconnected.

A-30 Cable Continuity Interlock Receiver Circuit. Figure A-3 shows the cable continuity interlock circuit. The three input voltage divider resistors are selected so that a 3 common input will cause A4Q1 to saturate and an open (no input con-

nection) will cause A4Q1 to cut off. The maximum current (I_{SC-MAX}) that could be drawn from the input circuit when the input terminals are short circuited is 6mA. The maximum voltage (E_{OC-MAX}) that appears across the input terminals under open circuit conditions is 8V.

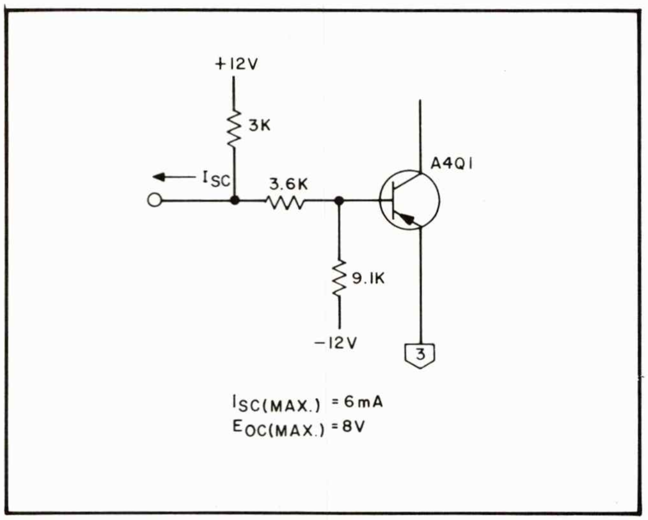


Figure A-3. Cable Continuity Interlock Receiver Circuit

A-31 INPUT GROUND

A-32 Input data common must be connected to ③ common of the DVS (pins 26 through 31 shown on Figure A-1). These pins are internally shorted together within the connector jack.

A-33 OUTPUT DRIVER CIRCUITS

A-34 Figure A-4 shows the output driver circuit that is used for each digital output signal; namely, flag, overload status, and latch status. "Open collector" type drivers are used. Each transistor can withstand up to 20V across it in the cutoff condition and can conduct up to 20mA of current when saturated. The output is "high" (more positive) when the driver is cut off or "low" (less positive) when the driver is conducting. Output impedances under these conditions are shown on the drawing.

A-35 FLAG OUTPUT

A-36 Flag output signals are issued under three separate conditions. As described in Section III the flag output switches from ready to busy during: (1) processing of the voltage magnitude data bits, (2) changing of the voltage range, and (3) current overload periods. The time that the flag remains in the busy state is different for each of the three conditions (see Figures 3-4, 3-5, and 3-7).

A-37 Flag Polarity. For this option, transistor

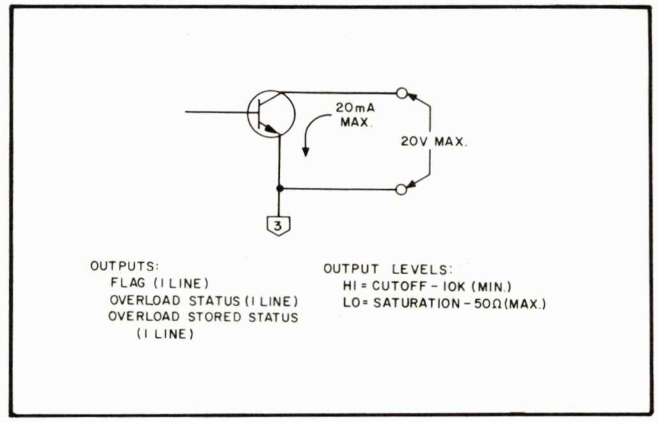
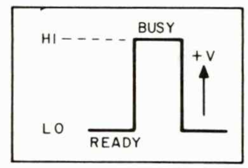


Figure A-4. Driver Circuit

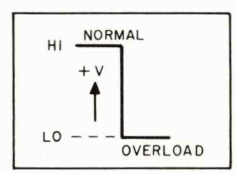
A1Q6 and resistor A1R15 and A1R17 are included, jumper W14 is not installed, and, therefore, the flag polarity is as follows:



A-38 OVERLOAD STATUS

A-39 The overload status line switches to the overload state whenever the output current exceeds the programmed current latch value (see Figure 3-7). The signal remains in the overload state until the output current is decreased (unit goes into current latch or overload is removed).

A-40 Overload Status Polarity. For this Option transistor A6A6Q4 and resistor A6A6R7 are not supplied and jumper A6A6W2 is installed. Therefore transistor A6A6Q3 serves as the output driver and the output signal is as follows:



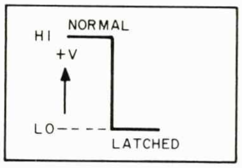
A-41 LATCH STATUS

A-42 The latch status line switches to the latched state if the unit goes from the overload to the latch state (Figure 3-7). In the latch condition, the output current is limited to less than 10mA. The latch status signal will revert from the overload latch state to the normal state approximately 10μsec after the next gate input is received, providing that the overload condition no longer exists. Therefore, to program the DVS out of the current latch condition and back to normal operation, the overload must be removed or the current latch setting increased; and then a new gate signal must be issued.

A-43 The latch status signal does not switch to

the latch state if the C_T terminals on the rear of the DVS are shorted (refer to Paragraph 3-33).

A-44 <u>Latch Status Polarity</u>. For this Option, transistor A6A5Q4 serves as the output driver. The signal polarity is as follows:



A-45 POCKET PROGRAMMER 14533B USAGE

A-46 To program the DVS using the HP Pocket Programmer 14533B, refer to the adjacent chart for appropriate switch positions for this particular option. Note that these switch positions may not apply to the "A" version of the Pocket Programmer 14533B.

A-47 OPTION 061 PARTS LIST

A-48 The following is a tabular listing of the special parts associated with this Option.

SWITCH	POSITION		
Voltage Magnitude (A8-D1)			
Binary 1	down		
Binary 0	up		
Output Sign			
Positive Output	up		
Negative Output	down		
Current Latch (L22, L23, L24)	L22	L23	L24
20mA	up	up	up
50mA	down	up	up
70mA	up	down	up
100mA	down	down	up
200mA	up	up	down
500mA	down	up	down
MP/-DCPS	down		
Input Level Reference	down		

Option 061 Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A1	Input Board	1		28480	5060-7987	
A1A1R1	fxd, comp 1KΩ ±5%, 1/4W	1	CB-1025	01121	0683-1025	1
A1A1R2	fxd, comp 2KΩ ±5%, 1/4W	1	CB-2025	01121	0683-2025	1
A1A1R3	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
A1A2 through A1A17	Same as A1A1	16				
A1Q1	Omit Q1					
A1Q6	SS NPN Si	1		28480	1854-0071	1
A1Q7	Omit Q7					
A1R1	fxd, comp 1KΩ ±5%, 1/4W	1	CB-1025	01121	0683-1025	1
A1R2	fxd, comp 2KΩ ±5%, 1/4W	1	CB-2025	01121	0683-2025	1
A1R3	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
A1R4	Omit R4					
A1R15	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
A1R17	fxd, comp 2.7Ω ±5%, 1/4W	1	CB-0275	01121	0683-0275	1
A1R18, 19	Omit R18 and R19					
A1VR5	Omit VR5					
A2	Logic Board	1		28480	5060-7991	
A2A1Z1	Quad, D-Type Latch, IC	4	SN7475	01295	1820-0301	4

Option 061 Replaceable Parts (Continued)

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A2A2Z1 through A2A4Z1	Same as A2A1Z1					
A2A1Z7 through A2A4Z7	Omit Z7 (SN7475's are installed in Z1 locations)					
A6	Control Board	1		28480	5060-7994	
A1A1R1	fxd, comp 1KΩ ±5%, 1/4W	1	CB-1025	01121	0683-1025	1
A6A1R2	fxd, comp 2KΩ ±5%, 1/4W	1	CB-2025	01121	0683-2025	1
A6A1R3	fxd, comp 10KΩ ±5%, 1/4W	1	CB-1035	01121	0683-1035	1
A6A2 through A6A4	Same As A6A1	3				
A6A5R8	Omit A6A5R8					
A6A5VR1	Omit A6A5VR1					
A6A6Q4	Omit A6A6Q4					
A6A6R7,8	Omit A6A6R7,R8					
A6A6VR1	Omit A6A6VR1					
A6CR14,15	Diode, Si 200mA 75V	2		28480	1901-0050	2

APPENDIX B
OPTION 063-BCD Interface For Microcircuit Logic Levels

B-1 INTRODUCTION

B-2 This Appendix describes the input and output data parameters for interfacing with a digital source employing microcircuits of the TTL or DTL family. Only interfacing requirements are discussed in this Appendix. Information of a more general nature is given in Section III of this manual. Hence, for a complete conception of the operating and interfacing requirements, both this Appendix and Section III must be consulted.

B-3 The data parameters described in the following paragraphs include the following:

(1) BCD voltage magnitude data.
(2) Input/output signal polarity.
(3) Logic coding - significance of high and low input/output signal states.
(4) Logic levels - voltage limits for high and low digital signal states.

B-4 The digital input/output stages on three of the DVS plug-in boards (A1, A2, and A6) have been especially designed to obtain the desired data parameters under worst case conditions. A list of these parts is included at the rear of this Appendix.

B-5 DATA CONNECTOR

B-6 Input/output data is connected to the digital programming source by means of the rear connector (Figure B-1). The parameters associated with each of the signals of Figure B-1 are discussed in the following paragraphs.

B-7 INPUT/OUTPUT SIGNAL POLARITY

B-8 All input/output signals are of positive polarity; i.e. are above 0 volts.

B-9 RECEIVER CIRCUITS AND LOGIC LEVELS

B-10 Figure B-2 shows an input circuit that applies to all of the digital inputs. The three resistors of the input voltage divider are selected so that a high input level will turn-on the succeeding driver stage and a low input level will cut the

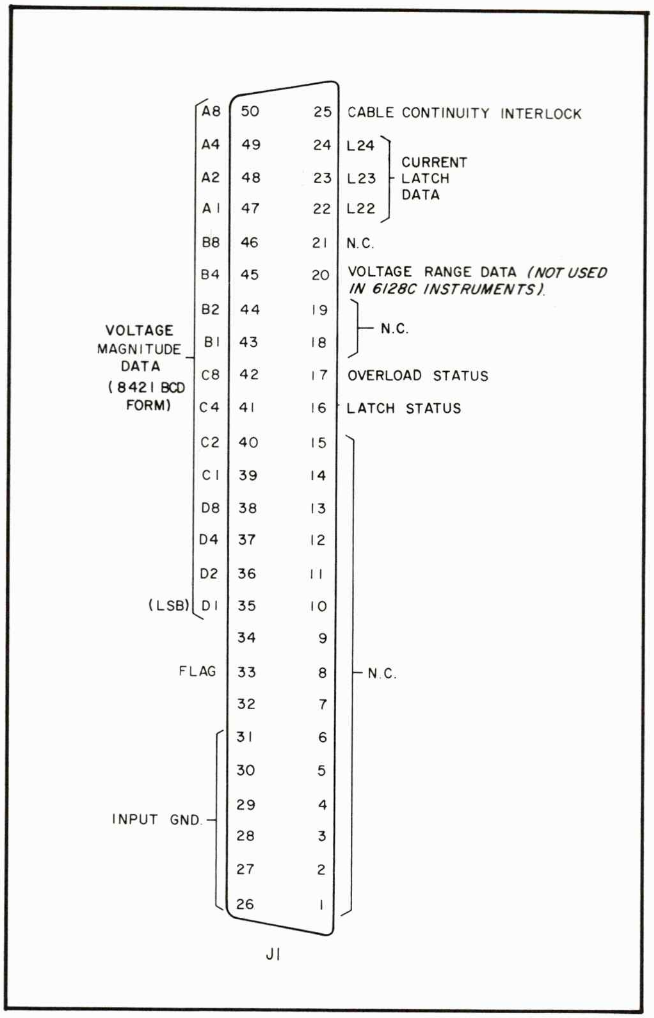


Figure B-1. Input/Output Data Connector

stage off. As shown on Figure B-2, the logic levels for all of the listed inputs are high = +1.9V to +16.5V and low = -4.4V to +1.3V.

B-11 The maximum current that can be drawn from the input circuit when the input terminals are short circuited as 1mA (designated I_{SC-MAX} on Figure B-2). The maximum voltage can appear across the input terminals under open circuit conditions (designated E_{OC-MAX}) is 3.8V.

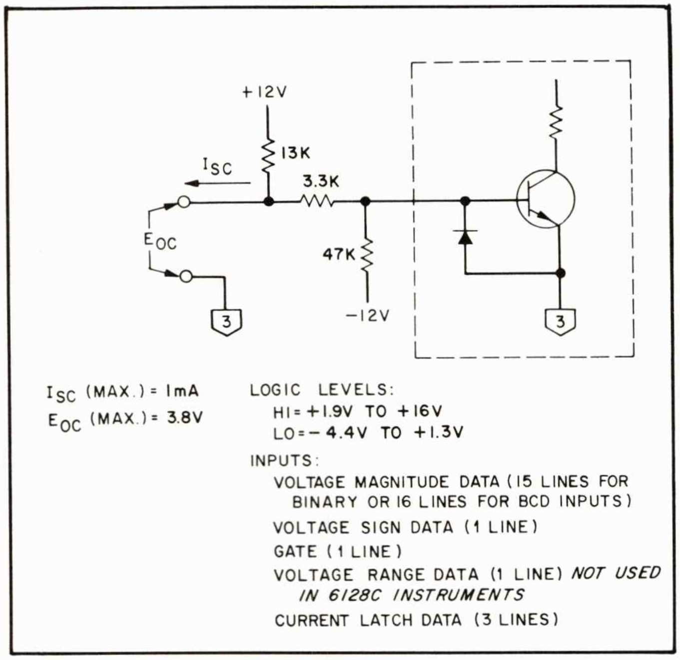
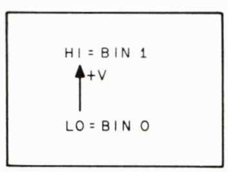


Figure B-2. Receiver Circuit

B-12 VOLTAGE MAGNITUDE INPUT DATA

B-13 Logic Type. The input data to the unit is received in a 8-4-2-1 binary-coded decimal form on 16 lines.

B-14 Logic Coding.



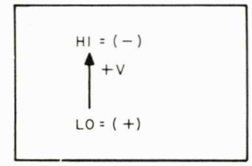
B-15 Logic Inversion. In order to provide the logic coding described above, the four storage IC's on the A2 board are located in the Z7 (rather than the Z1) sockets so that they perform a signal inversion.

B-16 The 4 digit, (A through D) 16 bit voltage magnitude data is used in conjunction with the voltage range and voltage sign bits to control the output voltage of the DVS. The voltage sign input determines the polarity (+ or -) of the output voltage while the voltage range input multiplies the BCD voltage data by X1 or X10.

B-17 VOLTAGE SIGN

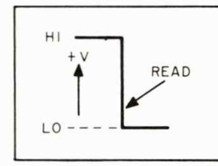
B-18 The voltage sign data bit determines the polarity of the output. Jumper connections A2W1-A and A2W2-A (Figure 7-2, Sheet 1) are included for the coding shown below.

B-19 Logic Coding.



B-20 GATE

B-21 Logic Coding. As shown, a high to low transition of the gate input permits storage of the voltage magnitude, voltage sign, current latch, and voltage range input data in the DVS storage registers. The STORAGE switch on the A2 P.C. Board (see Figure 3-2) must be in the STORE position to utilize this storage capability. Optional inverter stage A1Q1 is not used in this instrument.



B-22 VOLTAGE RANGE

B-23 Coding. HI = X10 (High voltage range).
LO = X1 (Low voltage range).

B-24 The following chart shows the coding required for voltage range.

INPUT CODE	
Voltage Range Bit	VOLTAGE RANGE
LO	X1
HI	X10

B-25 CURRENT LATCH

B-26 Coding. The current latch data forms a 3-bit binary code. The input codes for each current latch value are shown in the chart on page 3-5. Notice that the three current latch bits provide a maximum of six possible combinations.

B-27 C_T Terminals. As described in Section III, the current latch delay period is determined by the condition of the C_T terminals at the rear of the unit. Notice that if the C_T terminals are shorted, the DVS will not current latch even if the output current exceeds the programmed current latch value.

B-28 CABLE CONTINUITY INTERLOCK

B-29 Before output voltage can be obtained from the DVS, a connection must be made between input common ($\boxed{3}$) and the cable continuity interlock pin 25 of the input/output connector. If this connection is not made, the output terminals of the DVS will be shorted by an internal relay. This protects the load device against excessive voltages in case the input cable is disconnected.

B-30 Cable Continuity Interlock Receiver Circuit. Figure B-3 shows the cable continuity interlock

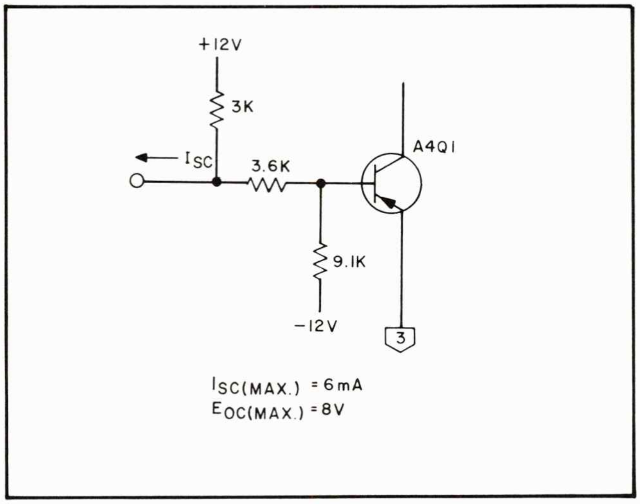


Figure B-3. Cable Continuity Interlock Receiver Circuit

receiver circuit. The three input voltage divider resistors are selected so that a $\boxed{3}$ common input will cause A4Q1 to saturate and an open (no input connection) will cause A4Q1 to cut off. The maximum current (I_{SC-MAX}) that could be drawn from the input circuit when the input terminals are short circuited is 6mA. The maximum voltage (E_{OC-MAX}) that appears across the input terminals under open circuit conditions is 8V.

B-31 INPUT GROUND

B-32 Input data must be connected to $\boxed{3}$ common of the DVS (pins 26 through 31) shown on Figure B-1. These pins are internally shorted together within the connector jack.

B-33 OUTPUT DRIVER CIRCUITS

B-34 Figure B-4 shows the output driver circuit that is used for each output signal; namely, flag, overload status, and latch status. Transistors A1Q5, A6A5A4, and A6A6Q3 serve as the output driver transistors. A zener diode in each output circuit prevents the output voltage from exceeding + 4.4V (max) when the output driver is cut off (high output condition).

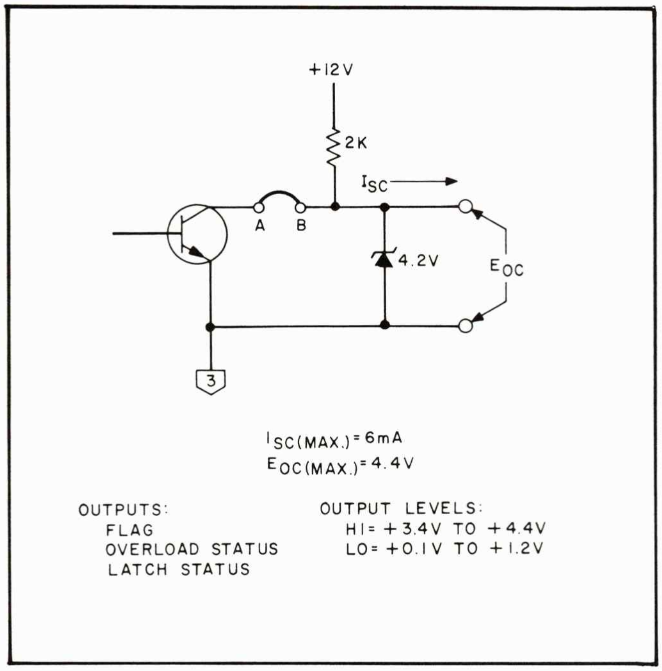


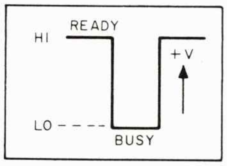
Figure B-4. Driver Circuit

B-35 With the output terminals shorted, the maximum current (I_{SC-MAX}) that can be drawn from the driver circuit is 6mA. With the output terminals open, the maximum voltage (as determined by the zener diode) is + 4.4V.

B-36 FLAG OUTPUT

B-37 Flag output signals are issued under three separate conditions. As described in Section III, the flag output switches from ready to busy during: (1) processing of the voltage magnitude data bits, (2) changing of the voltage range, and (3) current overload periods. The time that the flag remains in the busy state is different for each of the three conditions (see Figures 3-4, 3-5, and 3-7).

B-38 Flag Polarity. For this option, transistor A1Q6 and resistor A1R15 are not supplied, jumpers W14 and W15 are installed, and resistor R18 (the load for A1Q5) and zener diode A1VR5 are included. The flag polarity, therefore, is as follows:

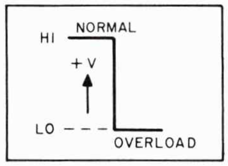


B-39 OVERLOAD STATUS

B-40 The overload status line switches to the

overload state whenever the output current exceeds the programmed current latch value (see Figure 3-7). The signal remains in the overload state until the output current is decreased (unit goes into current latch or overload is removed).

B-41 Overload Status Polarity. For this option, transistor A6A6Q4 and resistor A6A6R7 are not supplied and jumper A6A6Q3 serves as the output transistor with resistor A6A6R8 (load for A6A6Q3) and zener diode A6A6VR1 included. The output signal polarity is as follows:

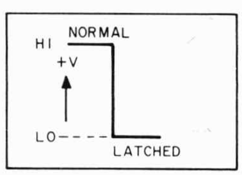


B-42 LATCH STATUS

B-43 The latch status line switches to the latch state if the unit goes from the overload to the latch state (Figure 3-7). In the latch condition, the output current is limited to less than 10mA. The latch status signal will revert from the overload latch state to the normal state approximately 10μsec after the next gate input is received, providing that the overload condition no longer exists. Therefore, to program the DVS out of the current latch condition and back to normal operation, the overload must be removed or the current latch setting increased; and then a new gate signal must be issued.

B-44 The latch status signal does not switch to the latched state if the C_T terminals on the rear of the DVS are shorted (refer to Paragraph 3-33).

B-45 Latch Status Polarity. For this Option, Transistor A6A5Q4 serves as the output driver with resistor A6A5R8 installed for its load. Zener diode A6A5VR1 is included. The output signal polarity is as follows:



SWITCH	POSITION		
Voltage Magnitude (A8-D1)			
Binary 1	up		
Binary 0	down		
Output Voltage			
Positive Output	down		
Negative Output	up		
Current Latch (L22, L23, L24)	L22	L23	L24
20mA	up	up	up
50mA	down	up	up
70mA	up	down	up
100mA	down	down	up
200mA	up	up	down
500mA	down	up	down
MP/DCPS	down		
Input Level Reference	down		

B-46 POCKET PROGRAMMER 14533B USAGE

B-47 To program the DVS using the HP Pocket Programmer 14533B, refer to the preceding chart for approriate switch positions for this particular option. Note that these switch positions may not apply to the "A" version of the Pocket Programmer 14533A.

B-48 OPTION 063 PARTS LIST

B-49 The following is a tabular listing of the special parts associated with this Option.

Option 063 Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A1	Input Board	1		28480	5060-7988	
A1A1R1	fxd, comp 13KΩ ±5%, 1/4W	1	CB-1335	01121	0683-1335	1
A1A1R2	fxd, comp 3.3KΩ ±5%, 1/4W	1	CB-3325	01121	0683-3325	1
A1A1R3	fxd, comp 47KΩ ±5%, 1/4W	1	CB-4735	01121	0683-4735	1

Option 063 Replaceable Parts (Continued)

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
A1A2 through A1A17	Same as A1A1	16				
A1Q1,6,7	Omit Q1,Q6,Q7					
A1R1	fxd, comp 13KΩ ±5%, 1/4W	1	CB-1335	01121	0683-1335	1
A1R2	fxd, comp 3.3KΩ ±5%, 1/4W	1	CB-3325	01121	0683-3325	1
A1R3	fxd, comp 47KΩ ±5%, 1/4W	1	CB-4735	01121	0683-4735	1
A1R4,15, 17	Omit R4, R15, R17					
A1R18	fxd, comp 2KΩ ±5%, 1/4W	1	CB-2025	01121	0683-2025	1
A1R19	Omit R19					
A1VR5	Diode, zener 4.22V ±5%	1		28480	1902-3070	1
A2	Logic Board	1		28480	5060-7992	
A2A1Z1 through A2A4Z1	Omit Z1 (SN7475's are installed in Z7 locations)					
A2A1Z7	Quad, D-Type Latch, IC	4	SN7475	01295	1820-0301	4
A2A2Z7 through A2A4Z7	Same as A2A1Z7					
A6	Control Board	1		28480	5060-7995	
A6A1R1	fxd, comp 13KΩ ±5%, 1/4W	1	CB-1335	01121	0683-1335	1
A6A1R2	fxd, comp 3.3KΩ ±5%, 1/4W	1	CB-3325	01121	0683-3325	1
A6A1R3	fxd, comp 47KΩ ±5%, 1/4W	1	CB-4735	01121	0683-4735	1
A6A2 through A6A4	Same as A6A1	3				
A6A5R8	fxd, comp 2KΩ ±5%, 1/2W	1	EB-2025	01121	0686-2025	1
A6A5VR1	Diode, zener 4.22V ±5%	1		28480	1902-3070	1
A6A6Q4	Omit A6A6Q4					
A6A6R7	Omit A6A6R7					
A6A6R8	fxd, comp 2KΩ ±5%, 1/2W	1	EB-2025	01121	0686-2025	1
A6A6VR1	Diode, zener 4.22V ±5%	1		28480	1902-3070	1
A6CR14,15	Diode, Si 200mA 75V	2		28480	1901-0050	2

HEWLETT hp PACKARD

SALES & SERVICE OFFICES

AFRICA, ASIA, AUSTRALIA

ANGOLA
Telectra
Empresa Técnica de
Equipamentos
Eléctricos, S.A.R.L.
R. Barbosa Rodrigues, 42-I°DT.°
Caixa Postal, 6487
Luanda
Tel: 35515/6
Cable: TELECTRA Luanda

AUSTRALIA
Hewlett-Packard Australia
Pty. Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
P.O. Box 36
Doncaster East, Victoria 3109
Tel: 89-6351
Telex: 31-024
Cable: HEWPARD Melbourne

Hewlett-Packard Australia
Pty. Ltd.
31 Bridge Street
Pymble
New South Wales, 2073
Tel: 449-6566
Telex: 21561
Cable: HEWPARD Sydney

Hewlett-Packard Australia
Pty. Ltd.
153 Greenhill Road
Parkside, S.A., 5063
Tel: 272-5911
Telex: 82536
Cable: HEWPARD Adelaide

Hewlett-Packard Australia
Pty.Ltd.
141 Stirling Highway
Nedlands, W.A. 6009
Tel: 86-5455
Telex: 93859
Cable: HEWPARD Perth

Hewlett-Packard Australia
Pty. Ltd.
121 Wollongong Street
Fyshwick, A.C.T. 2609
Tel: 95-2733
Telex: 62650
Cable: HEWPARD Canberra

Hewlett Packard Australia
Pty. Ltd.
5th Floor
Teachers Union Building
495-499 Boundary Street
Spring Hill, 4000 Queensland
Tel: 229-1544
Cable: HEWPARD Brisbane

GUAM
Medical/Personal Calculators Only
Guam Medical Supply, Inc.
Jay Ease Building, Room 210
P.O. Box 8947
Tamuning 96911
Tel: 646-4513
Cable: EARMED Guam

HONG KONG
Schmidt & Co.(Hong Kong) Ltd.
P.O. Box 297
Connaught Centre,
39th Floor
Connaught Road, Central
Hong Kong
Tel: H-255291-5
Telex: 74766 SCHMC HX
Cable: SCHMIDTCO Hong Kong

INDIA
Blue Star Ltd.
Kasturi Buildings
Jamshedji Tata Rd
Bombay 400 020
Tel: 29 50 21
Telex: 011-2156
Cable: BLUEFROST

Blue Star Ltd.
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
Bombay 400 025
Tel: 45 78 87
Telex: 011-4093
Cable: FROSTBLUE

Blue Star Ltd.
Band Box House
Prabhadevi
Bombay 400 025
Tel: 45 73 01
Telex: 011-3751
Cable: BLUESTAR

Blue Star Ltd.
7 Hare Street
P.O. Box 506
Calcutta 700 001
Tel: 23-0131
Telex: 021-7655
Cable: BLUESTAR

Blue Star Ltd.
Bhandari House
7th & 8th Floor
91 Nehru Place
New Delhi 110 024
Tel: 634770 & 635166
Telex: 031-2463
Cable: BLUESTAR

Blue Star Ltd.
Blue Star House
11/11A Magarath Road
Bangalore 560 025
Tel: 55668
Telex: 043-430
Cable: BLUESTAR

Blue Star Ltd.
Meeakshi Mandiram
xxx/1678 Mahatma Gandhi Rd.
Cochin 682 016
Tel: 32069,32161,32282
Telex: 0885-514
Cable: BLUESTAR

Blue Star Ltd.
1-1-117/1
Sarojini Devi Road
Secunderabad 500 003
Tel: 70126, 70127
Telex: 015-459
Cable: BLUEFROST

Blue Star Ltd.
2/34 Kodambakkam High Road
Madras 600 034
Tel: 82056
Telex: 041-379
Cable: BLUESTAR

INDONESIA
BERCA Indonesia P.T.
P.O. Box 496/Jkt.
Jln.Abdul Muis 62
Jakarta
Tel: 40369, 49886,49255,356038
Telex: Jkt.42895
Cable: BERCACON

BERCA Indonesia P.T.
P.O. Box 174/Sby.
23 Jln. Jimerto
Surabaya
Tel: 42027
Cable: BErcacon

ISRAEL
Electronics Engineering Div.
of Motorola Israel Ltd.
16, Kremenetski Street
P.O.Box 25016
Tel-Aviv
Tel: 38973
Telex: 33569
Cable: BASTEL Tel-Aviv

JAPAN
Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg., 4th Floor
4-20, Nishinakajima 5-chome
Yodogawa-ku, Osaka-shi
Osaka,532
Tel: 06-304-6021
Telex: 523-3624

Yokogawa-Hewlett-Packard Ltd.
29-21, Takaido-Higashi 3-chome
Suginami-ku, **Tokyo** 168
Tel: 03-331-6111
Telex: 232-2024 YHP-Tokyo
Cable: YHPMARKET TOK 23 724

Yokogawa-Hewlett-Packard Ltd.
Nakamo Building
24 Kami Sasajima-cho
Nakamura-ku, **Nagoya**, 450
Tel: 052 571-5171

Yokogawa-Hewlett-Packard Ltd.
Tanigawa Building
2-24-1 Tsuruya-cho
Kanagawa-ku
Yokohama, 221
Tel: 045-312-1252
Telex: 382-3204 YHP YOK

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Building
105, 1-chome, San-no-maru
Mito, Ibaragi 310
Tel: 0292-25-7470

Yokogawa-Hewlett-Packard Ltd.
Inoue Building
1348-3, Asahi-cho, 1-chome
Atsugi, Kanagawa 243
Tel: 0462-24-0452

Yokogawa-Hewlett-Packard Ltd.
Kumagaya Asahi
Hachijuni Building
4th Floor
3-4, Tsukuba
Kumagaya, Saitama 360
Tel: 0485-24-6563

KENYA
Technical Engineering
Services(E.A.)Ltd.
P.O. Box 18311
Nairobi
Tel: 55679/556680/557726
Telex: 22629
Cable: PROTON

Medical Only
International Aeradio(E.A.)Ltd.
P.O. Box 19012
Nairobi Airport
Nairobi
Tel: 336055/56
Telex: 22201/22301
Cable: INTAERIO Nairobi

KOREA
Samsung Electronics Co., Ltd.
15th Floor, Daeyongak Bldg.,
25-5, 1-KA
Choong Moo-Ro, Chung-Ku,
Seoul
Tel: (23) 6811, 778-3401/2/3/4
Telex: 2257S
Cable: ELEKSTAR Seoul

MALAYSIA
Teknik Mutu Sdn. Bhd.
No. 2, Lorong 13/6A
Section 13
Petaling Jaya,**Selangor**
Tel: 54994/54916
Telex: MA 37605

Protel Engineering
P.O. Box 1917
Lot 259, Satok Road
Kuching, **Sarawak**
Tel: 53544
Cable: PROTELENG

MOZAMBIQUE
A.N. Goncalves, Ltd.
162, 1° Apt. 14 Av. D. Luis
Caixa Postal 107
Maputo
Tel: 27091, 27114
Telex: 6-203 NEGON Mo
Cable: NEGON

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
4-12 Cruickshank Street
Kilbirnie, Wellington 3
P.O. Box 9443
Courtney Place
Wellington
Tel: 877-199
Cable: HEWPACK Wellington

Hewlett-Packard (N.Z.) Ltd.
Pakuranga Professional Centre
267 Pakuranga Highway
Box 51092
Pakuranga
Tel: 569-651
Cable: HEWPACK Auckland

Analytical/Medical Only
Medical Supplies N.Z. Ltd.
Scientific Division
79 Carlton Gore Road, Newmarket
P.O. Box 1234
Auckland
Tel: 75-289
Cable: DENTAL Auckland

Analytical/Medical Only
Medical Supplies N.Z. Ltd.
Private Bag
Norrie and Parumoana Streets
Porirua
Tel: 75-098
Telex: 3858

Analytical/Medical Only
Medical Supplies N.Z. Ltd.
P.O. Box 309
239 Stanmore Road
Christchurch
Tel: 892-019
Cable: DENTAL Christchurch

Analytical/Medical Only
Medical Supplies N.Z. Ltd.
303 Great King Street
P.O. Box 233
Dunedin
Tel: 88-817
Cable: DENTAL Dunedin

NIGERIA
The Electronics
Instrumentations Ltd.
N6B/770 Oyo Road
Oluseun House
P.M.B. 5402
Ibadan
Tel: 61577
Telex: 31231 TEIL Nigeria
Cable: THETEIL Ibadan

The Electronics Instrumentations Ltd.
144 Agege Motor Road, Mushin
P.O. Box 6645
Lagos
Cable: THETEIL Lagos

PAKISTAN
Mushko & Company Ltd.
Oosman Chambers
Abdullah Haroon Road
Karachi-3
Tel: 511027, 512927
Telex: 2894
Cable: COOPERATOR Karachi

Mushko & Company, Ltd.
38B, Satellite Town
Rawalpindi
Tel: 41924
Cable: FEMUS Rawalpindi

PHILIPPINES
The Online Advanced
Systems Corporation
Rico House
Amorsolo cor. Herrera Str.
Legaspi Village, Makati
P.O. Box 1510
Metro **Manila**
Tel: 85-35-81, 85-34-91,85-32-21
Telex: 3274 ONLINE

RHODESIA
Field Technical Sales
45 Kelvin Road North
P.O. Box 3458
Salisbury
Tel: 705231 (5 lines)
Telex: RH 4122

SINGAPORE
Hewlett-Packard Singapore
(Pte.) Ltd.
1150 Depot Road
Alexandra P.O. Box 58
Singapore 4
Tel: 270-2355
Telex: HPSG RS 21486
Cable: HEWPACK, Singapore

SOUTH AFRICA
Hewlett-Packard South Africa
(Pty.), Ltd.
Private Bag Wendywood,
Sandton, Transvaal, 2144
Hewlett-Packard Centre
Daphne Street, Wendywood,
Sandton, 2144
Tel: 802-1040/8
Telex: 8-4782
Cable: HEWPACK Johannesburg

Hewlett-Packard South Africa
(Pty.), Ltd.
P.O. Box 120
Howard Place, Cape Province, 7450
Pine Park Centre, Forest Drive,
Pinelands, Cape Province, 7405
Tel: 53-7955 thu 9
Telex: 57-0006

TAIWAN
Hewlett-Packard Far East Ltd.
Taiwan Branch
39 Chung Hsiao West Road
Section 1, 7th Floor
Taipei
Tel: 3819160-4,3141010,3715121
Ext. 270-279
Cable: HEWPACK TAIPEI

Hewlett-Packard Far East Ltd.
Taiwan Branch
68-2, Chung Cheng 3rd. Road
Kaohsiung
Tel: (07) 242318-Kaohsiung

Analytical Only
San Kwang Instruments Co., Ltd.
20 Yung Sui Road
Taipei
Tel: 3715171-4 (5 lines)
Telex: 22894 SANKWANG
Cable: SANKWANG Taipei

TANZANIA
Medical Only
International Aeradio (E.A.), Ltd.
P.O. Box 861
Dar es Salaam
Tel: 21251 Ext. 265
Telex: 41030

THAILAND
UNIMESA Co. Ltd.
Elcom Research Building
2538 Sukumvit Ave.
Bangchak,Bangkok
Tel: 3932387, 3930338
Cable: UNIMESA Bangkok

UGANDA
Medical Only
International Aeradio(E.A.), Ltd.
P.O. Box 2577
Kampala
Tel: 54388
Cable: INTAERIO Kampala

ZAMBIA
R.J. Tilbury (Zambia) Ltd.
P.O. Box 2792
Lusaka
Tel: 73793
Cable: ARJAYTEE, Lusaka

OTHER AREAS NOT LISTED, CONTACT:
Hewlett-Packard Intercontinental
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 856-1501
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8300, 034-8493

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11620A - 168th Street
Edmonton T5M 3T9
Tel: (403) 452-3670
TWX: 610-831-2431

Hewlett-Packard (Canada) Ltd.
210,7220 Fisher St. S.E.
Calgary T2H 2H8
Tel: (403) 253-2713
Twx: 610-821-6141

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
10691 Shellbridge Way
Richmond V6X 2W7
Tel: (604) 270-2277
TWX: 610-925-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
380-550 Century St.
Winnipeg R3H 0Y1
Tel: (204) 786-6701
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
800 Windmill Road
Dartmouth B3B 1L1
Tel: (902) 469-7820
TWX: 610-271-4482 HFX

ONTARIO
Hewlett-Packard (Canada) Ltd.
1020 Morrison Dr.
Ottawa K2H 8K7
Tel: (613) 820-6483
TWX: 610-563-1636

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga L4V 1M8
Tel: (416) 678-9430
TWX: 610-492-4246

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Blvd.
Pointe Claire H9R 1G7
Tel: (514) 697-4232
TWX: 610-422-3022
TLX: 05-821521 HPCL

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada)
Ltd. in Mississauga.

CENTRAL AND SOUTH AMERICA

ARGENTINA
Hewlett-Packard Argentina
S.A.
Av. Leandro N. Alem 822 - 12°
1001 **Buenos Aires**
Tel: 31-6063,4,5,6
Telex: 122443 AR CIGY
Cable: HEWPACKARG

Biotron S.A.C.I.y M.
Bolivar 177
1066 **Buenos Aires**
Tel: 30-4846, 34-9356, 34-0460.
Telex: 17595

BOLIVIA
Casa Kavlin S.A.
Calle Potosi' 1130
P.O. Box 500
La Paz
Tel: 41530,53221
Telex: CWC BX 5298,ITT 3560082
Cable: KAVLIN

BRAZIL
Hewlett-Packard do Brasil
I.e.C. Ltda.
Alameda Rio Negro, 750
Alphaville
06400 **Barueri** SP
Tel: 429-3222
Cable: HEWPACK Sao Paulo

Hewlett-Packard do Brasil
I.e.C. Ltda.
Rua Padre Chagas, 32
90000-**Pórto Alegre**-RS
Tel: (0512) 22-2998, 22-5621
Cable: HEWPACK Porto Alegre

Hewlett-Packard do Brasil
I.e.C. Ltda.
Rua Siqueira Campos, 53
Copacabana
20000-**Rio de Janeiro**-RJ
Tel: 257-80-94-DDD (021)
Telex: 391-212-1905 HEWP-BR
Cable: HEWPACK
Rio de Janeiro

CHILE
Calcagni y Metcalfe Ltda.
Alameda 580-Of. 807
Casilla 2118
Santiago, 1
Tel: 398613
Telex: 3520001 CALMET
Cable: CALMET Santiago

COLOMBIA
Instrumentación
Henrik A. Langebaek & Kier S.A.
Carrera 7 No. 48-75
Apartado Aéreo 6287
Bogotá, I.D.E.
Tel: 69-88-77
Telex: 044-400
Cable: AARIS Bogotá

Instrumentacion
H.A. Langebaek & Kier S.A.
Apartado Aereo 54098
Medellin
Tel: 304475

COSTA RICA
Cientifica Costarricense S.A.
Avenida 2, Calle 5
San Pedro de Montes de Oca
Apartado 10159
San Jose
Tel: 24-38-20, 24-08-19
Telex: 2367 GALGUR CR
Cable: GALGUR

ECUADOR
Computadoras y Equipos
Electrónicos
P.O. Box 6423 CCI
Eloy Alfaro No. 1824,3°Piso
Quito
Tel: 453 482
Telex: 2548 CYEDE ED
Cable: Sagita-Quito

Medical Only
Hospitalar S.A.
Casilla 3590
Robles 625
Quito
Tel: 545-250
Cable: Hospitalar-Quito

EL SALVADOR
Instrumentacion y Procesamiento
Electronico de el Salvador
Bulevar de los Heroes 11-48
San Salvador
Tel: 252787

GUATEMALA
IPESA
Avenida Reforma 3-48,
Zona 9
Guatemala City
Tel: 316627,314786,66471-5,ext.9
Telex: 4192 Teletro Gu

MEXICO
Hewlett-Packard Mexicana,
S.A. de C.V.
Av. Periférico Sur No. 6501
Tepepan, Xochimilco
Mexico 23, D.F.
Tel: 905-676-4600
Telex: 017-74-507

Hewlett-Packard Mexicana,
S.A. de C.V.
Ave. Constitución No. 2184
Monterrey, N.L.
Tel: 48-71-32, 48-71-84
Telex: 038-410

NICARAGUA
Roberto Terán G.
Apartado Postal 689
Edificio Terán
Managua
Tel: 25114, 23412,23454,22400
Cable: ROTERAN Managua

PANAMA
Electrónico Balboa, S.A.
P.O. Box 4929
Calle Samuel Lewis
Cuidad de Panama
Tel: 64-2700
Telex: 3485126 Curundu,
Canal Zone
Cable: ELECTRON Panama

PERU
Compañía Electro Médica S.A.
Los Flamencos 145
San Isidro Casilla 1030
Lima 1
Tel: 41-4325
Telex: Pub. Booth 25424 SISIDRO
Cable: ELMED Lima

URUGUAY
Pablo Ferrando S.A.
Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Telex: 702 PUBLIC BOOTH PARA
PABLO FERRANDO TELEFONO
40-31-02
Cable: RADIUM Montevideo

VENEZUELA
Hewlett-Packard de Venezuela
C.A.
P.O. Box 50933
Caracas 105
Los Ruices Norte
3a Transversal
Edificio Segre
Caracas 107
Tel: 35-00-11 (20 lines)
Telex: 25146 HEWPACK
Cable: HEWPACK Caracas

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard
Inter-Americas
3200 Hillview Ave.
Palo Alto, California 94304
Tel: (415) 856-1501
TWX: 910-373-1260
Cable: HEWPACK Palo Alto
Telex: 034-8300, 034-8493

EUROPE, NORTH AFRICA AND MIDDLE EAST

AUSTRIA
Hewlett-Packard Ges.m.b.H.
Handelskai 52
P.O. Box 7
A-1205 **Vienna**
Tel: 351620-29
Cable: HEWPAK Vienna
Telex: 75923 hewpak a

BELGIUM
Hewlett-Packard Benelux
S.A./N.V.
Avenue du Col-Vert, 1,
(Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 0047,672-2240
Cable: PALOBEN Brussels
Telex: 23-494 paloben bru

CYPRUS
Kypronics
19 Gregorios Xenopoulos Street
P.O. Box 1152
Nicosia
Tel: 45628/29
Cable: Kypronics Pandehis
Telex: 3018

CZECHOSLOVAKIA
Vyvojova a Provozni Zakladna
Vyzkumnych Ustavu v Bechovicich
CSSR-25097 **Bechovice u Prahy**
Tel: 89 93 41
Telex: 121333

Institute of Medical Bionics
Vyskumny Ustav Lekarskej Bioniky
Jedlova 6
CS-88346
Bratislava-Kramare
Tel: 4251
Telex: 93229

DDR
Entwicklungslabor der TU Dresden
Forschungsinstitut Meinsberg
DDR-7305
Waldheim/Meinsberg
Tel: 37 667
Telex: 518741

Export Contact AG Zuerich
Guenther Forgber
Schlegelstrasse 15
1040 **Berlin**
Tel: 42-74-12
Telex: 111889

DENMARK
Hewlett-Packard A/S
Datavej 52
DK-3460 **Birkerod**
Tel: (02) 81 66 40
Cable: HEWPACK AS
Telex: 37409 hpas dk

Hewlett-Packard A/S
Navervej 1
DK-8600 **Silkeborg**
Tel: (06) 82 71 66
Telex: 37409 hpas dk
Cable: HEWPACK AS

EGYPT
I.E.A.
International Engineering Associates
24 Hussein Hegazi Street
Kasr-el-Aini
Cairo
Tel: 23 829
Telex: 2067
Cable: INTENGASSO

Mohamed Sami Amin
Sami Amin Trading Office
18 Abdel Aziz Gawish
Abdine-Cairo
Tel: 24932
Cable: SAMITRO CAIRO

FINLAND
Hewlett-Packard OY
Nahkahousuntie 5
P.O. Box 6
SF-00211 **Helsinki** 21
Tel: (90) 6923031
Cable: HEWPACKOY Helsinki
Telex: 12-1563 HEWPA SF

FRANCE
Hewlett-Packard France
Quartier de Courtaboeuf
Boite Postale No. 6
F-91401 **Orsay** Cedex
Tel: (1) 907 78 25
Cable: HEWPACK Orsay
Telex: 600048

Hewlett-Packard France
Bureau de vente de Lyon
"Le Saquin"
Chemin des Mouilles
B.P. 162
F-69130 **Ecully** Cedex
Tel: (78) 33 81 25,
Cable: HEWPACK Eculy
Telex: 31 06 17

Hewlett-Packard France
Bureau de vente de Toulouse
Péricentre de la Cépière
Chemin de la Cépière, 20
F-31300 **Toulouse-Le Mirail**
Tel:(61) 40 11 12
Cable: HEWPACK 51957
Telex: 510957

Hewlett-Packard France
Le Ligoures
Bureau de vente de Marseilles
Place Rouée de Villeneuve
F-13100 Aix-en-**Provence**
Tel: (42) 59 41 02
Cable: HEWPACK MARGN
Telex: 410770

Hewlett-Packard France
Bureau de vente de Rennes
2, Allee de la Bourgnette
B.P. 1124
F-35100 **Rennes** Cédex
Tel: (99) 51 42 44
Cable: HEWPACK 74912
Telex: 740912

Hewlett-Packard France
Bureau de vente de Strassbourg
18, rue du Canal de la Marne
F-67300 **Schiltigheim**
Tel: (88) 83.08.10/83.11.53
Telex: 890141
Cable: HEWPACK STRBG

Hewlett-Packard France
Bureau de vente de Lille
Immeuble Péricentre
Rue van Gogh
F-59650 **Villeneuve** d Ascq
Tel: (20) 91.41.25
Telex: 16.01.24F

Hewlett-Packard France
Bureau de Vente
Centre d' affaires Paris-Nord
Bâtiment Ampère
Rue de la Commune de Paris
B.P. 300
F-93153 **Le Blanc Mesnil Cédex**
Tel: (01) 931 88 50

Hewlett-Packard France
Bureau de vente de Bordeau
Av. du Pdt. Kennedy
F-33700 **Merignac**
Tel: (56) 97 22 69

GERMAN FEDERAL REPUBLIC
Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Berner Strasse 117
Postfach 560 140
D-6000 **Frankfurt** 56
Tel: (0611) 50-04-1
Cable: HEWPACKSA Frankfurt
Telex: 04 13249 hpffm d

Hewlett-Packard GmbH
Technisches Büro Böblingen
Herrenberger Strasse 110
D-7030 **Böblingen**, Württemberg
Tel: (0703) 667-1
Cable: HEWPACK Böblingen
Telex: 07265739 bbn

Hewlett-Packard GmbH
Technisches Büro Düsseldorf
Emanuel-Leutze-Str.1(Seestern)
D-4000 **Düsseldorf**
Tel: (0211) 59711
Telex: 085/86 533 hpdd d

Hewlett-Packard GmbH
Technisches Büro Hamburg
Wendenstrasse 23
D-2000 **Hamburg** 1
Tel: (040) 24 13 93
Cable: HEWPACKSA Hamburg
Telex: 21 63 032 hphh d

Hewlett-Packard GmbH
Technisches Büro Hannover
Am Grossmarkt 6
D-3000 **Hannover 91**
Tel: (0511) 46 60 01
Telex: 092 3259

Hewlett-Packard GmbH
Technisches Büro Nürnberg
Neumeyerstrasse 90
D-8500**Nürnberg**
Tel: (0911) 56 30 83
Telex: 0623 860

Hewlett-Packard GmbH
Technisches Büro München
Eschenstrasse 5
D-8021 **Taufkirchen**
Tel: (089) 6117-1

Hewlett-Packard GmbH
Technisches Büro Berlin
Kaithstrasse 2-4
D-1000 **Berlin** 30
Tel: (030) 24 90 86
Telex:018 3405 hpbln d

GREECE
Kostas Karayannis
8 Omirou Street
Athens 133
Tel: 32 30 303/32/37 731
Telex: 21 59 62 RKAR GR
Cable: RAKAR ATHENS

Analytical Only
INTECO
G. Papathanassiou & Co.
17 Marni Street
Athens 103
Tel: 5522 915/5221 989
Telex: 21 5329 INTE GR
Cable: INTEKNIKA

Medical Only
Technomed Hellas Ltd.
52 Skoufa Street
Athens 135
Tel: 3626 972
Telex: 21 4693
Cable: ETALAK

HUNGARY
MTA
Müszerügy és Méréstechnikai
Szolgalata
Hewlett-Packard Service
Lenin Krt. 67, P.O.Box 241
1391Budapest VI
Tel: 42 03 38
Telex: 22 51 14

ICELAND
Medical Only
Elding Trading Company Inc.
Hafnarnvoli - Tryggvagötu
P.O.Box 895
IS-**Reykjavik**
Tel: 1 58 20/1 63 03
Cable: ELDING Reykjavik

IRAN
Hewlett-Packard Iran Ltd.
No. 13, Fourteenth St.
Mir Emad Avenue
P.O. Box 41/2419
Tehran
Tel: 851082-5
Telex: 213405 hewp ir

IRELAND
Hewlett-Packard Ltd.
King Street Lane
GB-**Winnersh**, Wokingham
Berks, RG11 5AR
Tel: (0734) 78 47 74
Telex: 847178
Cable: Hewpie London

ITALY
Hewlett-Packard Italiana S.p.A.
Via Amerigo Vespucci 2
Casella postale 3645
I-20124 **Milano**
Tel: (02) 6251 (10 lines)
Cable: HEWPACKIT Milano
Telex: 32046

Hewlett-Packard Italiana S.p.A.
Via Pellizzo 9
I-35100 **Padova**
Tel: (049) 66 48 88
Telex: 41612 Hewpacki

Hewlett-Packard Italiana S.p.A.
Via G. Armellini 10
I-00143 **Roma**
Tel: (06) 54 69 61
Telex: 61514
Cable: HEWPACKIT Roma

Hewlett-Packard Italiana S.p.A.
Corso Giovanni Lanza 94
I-10133 **Torino**
Tel:(011) 682245/659308

Medical/Calculators Only
Hewlett-Packard Italiana S.p.A.
Via Principe Nicola 43 G/C
I-95126 **Catania**
Tel:(095) 37 05 04

Hewlett-Packard Italiana S.p.A.
Via Amerigo Vespucci, 9
I-80142 **Napoli**
Tel: (081) 33 77 11
Telex: 61.51.4 Via Rome

Hewlett-Packard Italiana S.p.A.
Via E. Masi, 9/B
I-40137 **Bologna**
Tel: (5l) 30 78 87

JORDAN
Mouasher Cousins Co.
P.O. Box 1387
Amman
Tel: 24907/39907
Telex: SABCO JO 1456
Cable: MOUASHERCO

KUWAIT
Al-Khaldiya Trading &
Contracting
P.O. Box 830-Safat
Kuwait
Tel:42 4910/41 1726
Telex: 2481 Areeg kt
Cable: VISCOUNT

LUXEMBURG
Hewlett-Packard Benelux
S.A./N.V.
Avenue du Col-Vert, 1
(Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 672 22 40
Cable: PALOBEN Brussels
Telex: 23 494

MOROCCO
Dolbeau
81 rue Karatchi
Casablanca
Tel: 22 41 82/87
Telex: 23051/22833
Cable: MATERIO

Gerep
190 Blvd. Brahim Roudani
Casablanca
Tel: 25 16 76/25 90 99
Telex: 23 739
Cable: GEREP-CASA

Cogedir
2 Rue d' Agadir, B.P. 156
Casablanca
Tel: 27 65 40
Telex: 21 737
Cable: COGEDIR

NETHERLANDS
Hewlett-Packard Benelux N.V.
Van Heuven Goedhartlaan 121
P.O. Box 667
NL-Amstelveen 1134
Tel: (020) 47 20 21
Cable: PALOBEN Amsterdam
Telex: 13 216 hepa nl

NORWAY
Hewlett-Packard A/S
Osterdalen 18
P.O. Box 34
N-1345 Osteraas
Tel: (02) 1711 80
Telex: 16621 hpnas n

POLAND
Biuro Informacji Technicznej
Hewlett-Packard
Ul Stawki 2, 6P
00-950 **Warszawa**
Tel: 33.25.88/39.67.43
Telex: 81 24 53 hepa pl

UNIPAN
Biuro Obslugi Technicznej
01-447 Warszawa
ul **Newelska** 6
Poland

Zakłady Naprawcze Sprzetu
Medycznego
Plac Komuny Paryskiej 6
90-007 **Lódz**
Tel: 334-41, 337-83
Telex: 886981

PORTUGAL
Telectra-Empresa Técnica de
Equipamentos Eléctricos S.a.r.l.
Rua Rodrigo da Fonseca 103
P.O. Box 2531
P-**Lisbon** 1
Tel: (19) 68 60 72
Cable: TELECTRA Lisbon
Telex: 12598

Medical only
Mundinter
Intercambio Mundial de Comércio
S.a.r.l.
P.O. Box 2761
Avenida Antonio Augusto
de Aguiar 138
P - **Lisbon**
Tel: (19) 53 21 31/7
Telex: 16691 munter p
Cable: INTERCAMBIO Lisbon

RUMANIA
Hewlett-Packard Reprezentanta
Bd.n. Balcescu 16
Bucuresti
Tel: l5 80 23/13 88 85
Telex: 10440

I.I.R.U.C.
Intreprinderea Pentru
Intretinerea
Si Repararea Utilajelor de Calcul
B-dul Prof. Dimitrie Pompei 6
Bucuresti-Sectorul 2
Tel: 88-20-70, 88-24-40, 88-67-95
Telex: 118

SAUDI ARABIA
Modern Electronic
Establishment (Head Office)
P.O. Box 1228, Baghdadiah Street
Jeddah
Tel: 27 798
Telex: 40035
Cable: ELECTA JEDDAH

Modern Electronic
Establishment (Branch)
P.O. Box 2728
Riyadh
Tel: 62596/66232
Cable: RAOUFCO

Modern Electronic
Establishment (Branch)
P.O. Box 193
Al-Khobar
Tel: 44678-44813
Telex: 67044 OTESTA
Cable: ELECTA AL-KHOBAR

SPAIN
Hewlett-Packard Española, S.A.
Calle Jerez 3
E-**Madrid** 3
Tel: (1) 458 26 00 (10 lines)
Telex: 23515 hpe

Hewlett-Packard Española, S.A.
Milanesado 21-23
E-**Barcelona** 17
Tel: (3) 203 6200 (5 lines)
Telex: 52603 hpbe e

Hewlett-Packard Española, S.A.
Av Ramón y Cajal, 1
Edificio Sevilla, planta 9°
Seville 5
Tel: 64 44 54/58

Hewlett-Packard Española S.A.
Edificio Albia II 7° B
E-**Bilbao** 1
Tel: 23 83 06/23 82 06

Hewlett-Packard Española S.A.
C/Ramon Gordillo 1
(Entlo.)
E-**Valencia**-10
Tel: 96-361.13.54/361.13.58

SWEDEN
Hewlett-Packard Sverige AB
Enighetsvägen 3, Fack
S-161 **Bromma** 20
Tel: (08) 730 05 50
Telex: 10721
Cable: MEASUREMENTS
Stockholm

Hewlett-Packard Sverige AB
Frötallisgatan 30
S-421 32 **Västra Frölunda**
Tel: (031) 49 09 50
Telex: 10721 via Bromma office

SWITZERLAND
Hewlett-Packard (Schweiz) AG
Zürcherstrasse 20
P.O. Box 307
CH-8952 **Schlieren-Zurich**
Tel: (01) 7305240
Telex: 53933 hpag ch
Cable: HPAG CH

Hewlett-Packard (Schweiz) AG
Château Bloc 19
CH-1219 **Le Lignon-Geneva**
Tel: (022) 96 03 22
Telex: 27333 hpag ch
Cable: HEWPACKAG Geneva

SYRIA
General Electronic Inc.
Nuri Basha-Ahnaf Ebn Kays Street
P.O. Box 5781
Damascus
Tel: 33 24 87
Telex: 11215 ITIKAL
Cable: ELECTROBOR DAMASCUS

Medical/Personal Calculator only
Sawah & Co.
Place Azmé
B.P. 2308
Damascus
Tel: 16 367-19 697-14 268
Telex: 11304 SATACO SY
Cable: SAWAH, DAMASCUS

Suleiman Hilal El Mlawi
P.O. Box 2528
Mamoun Bitar Street, 56-58
DamascusTel: 11 46 63
Telex: 11270
Cable: HILAL DAMASCUS

TUNISIA
Tunisie Electronique
31 Avenue de la Liberte
Tunis
Tel: 280 144

Corema
1 ter. Av. de Carthage
Tunis
Tel: 253 821
Telex: 12319 CABAM TN

TURKEY
TEKNIM Company Ltd.
Riza Sah Pehlevi
Caddesi No. 7
Kavaklidere, **Ankara**
Tel: 275800
Telex: 42155 TKNM TR

Medical only
E.M.A.
Muhendislik Kollektif Sirketi
Mediha Eldem Sokak 41/6
Yüksel Caddesi
Ankara
Tel: 17 56 22
Cable: EMATRADE/Ankara

Analytical only
Yilmaz Ozyurek
Milli Mudafaa Cad 16/6
Kizilay
Ankara
Tel: 25 03 09 - 17 80 26
Telex: 42576 OZEK TR
Cable: OZYUREK ANKARA

UNITED ARAB EMIRATES
Emitac Ltd.
P.O. Box 1641
Sharjah
Tel: 24121-3
Telex: 8136 EMITAC SH
Cable: EMITAC SHARJAH

UNITED KINGDOM
Hewlett-Packard Ltd.
King Street Lane
GB-**Winnersh**, Wokingham
Berks, RG11 5AR
Tel: (0734) 78 47 74
Cable: Hewpie London
Telex:847178/9

Hewlett-Packard Ltd.
Trafalgar House
Navigation Road
Altrincham
Cheshire WA14 1NU
Tel: (061) 928 6422
Telex: 668068

Hewlett-Packard Ltd.
Lygon Court
Hereward Rise
Dudley Road
Halesowen,
West Midlands B62 8SD
Tel: (021) 550 9911
Telex: 339105

Hewlett-Packard Ltd.
Wedge House
799, London Road
GB-**Thornton Heath**
Surrey CR4 6XL
Tel: (01) 684 0103/8
Telex: 946825

Hewlett-Packard Ltd
10, Wesley St.
Castleford
Yorks WF10 1AE
Tel: (0977) 550016
Telex: 557355

Hewlett-Packard Ltd
1, Wallace Way
GB-**Hitchin**
Hertfordshire, SG4 0SE
Tel: (0462) 31111
Telex: 82.59.81

Hewlet-Packard Ltd
2C, Avonbeg Industrial Estate
Long Mile Road
Dublin 12
Tel: Dublin 514322/514224
Telex: 30439

USSR
Hewlett-Packard
Representative Office USSR
Pokrovsky Boulevard 4/17-kw 12
Moscow 101000
Tel: 207 59 24
Telex: 7825 hewpak su

YUGOSLAVIA
Iskra-Standard/Hewlett-Packard
Miklosiceva 38/VII
61000 **Ljubljana**
Tel: 31 58 79/32 16 74
Telex: 31583

SOCIALIST COUNTRIES NOT SHOWN PLEASE CONTACT:
Hewlett-Packard Ges.m.b.H
Handelskai 52
P.O. Box 7
A-1205 **Vienna**, Austria
Tel: (0222) 35 16 21 to 27
Cable: HEWPAK Vienna

MEDITERRANEAN AND MIDDLE EAST COUNTRIES NOT SHOWN PLEASE CONTACT:
Hewlett-Packard S.A.
Mediterranean and Middle
East Operations
35, Kolokotroni Street
Platia Kefallariou
GR-Kifissia-**Athens**, Greece
Tel: 8080337/359/429
Cable: HEWPACKSA Athens

FOR OTHER AREAS NOT LISTED CONTACT
Hewlett-Packard S.A.
7, rue du Bois-du-Lan
P.O. Box
CH-1217 Meyrin 2 - **Geneva**
Switzerland
Tel: (022) 82 70 00
Cable: HEWPACKSA Geneva

UNITED STATES

ALABAMA
P.O. Box 4207
8290 Whitesburg Dr.
Huntsville 35802
Tel: (205) 881-4591

8933 E. Roebuck Blvd.
Birmingham 35206
Tel: (205) 836-2203/2

ARIZONA
2336 E. Magnolia St.
Phoenix 85034
Tel: (602) 244-1361

2424 East Aragon Rd.
Tucson 85706
Tel: (602) 889-4661

***ARKANSAS**
Medical Service Only
P.O. Box 5646
Brady Station
Little Rock 72215
Tel: (501) 376-1844

CALIFORNIA
1430 East Orangethorpe Ave.
Fullerton 92631
Tel: (714) 870-1000

3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2671

5400 West Rosecrans Blvd.
P.O. Box 92105
World Way Postal Center
Los Angeles 90009
Tel: (213) 970-7500
TWX: 910-325-6608

***Los Angeles**
Tel: (213) 776-7500

3003 Scott Boulevard
Santa Clara 95050
Tel: (408) 249-7000
TWX: 910-338-0518

***Ridgecrest**
Tel: (714) 446-6165

646 W. North Market Blvd.
Sacramento 95834
Tel: (916) 929-7222

9606 Aero Drive
P.O. Box 23333
San Diego 92123
Tel: (714) 279-3200

***Tarzana**
Tel: (213) 705-3344

COLORADO
5600 DTC Parkway
Englewood 80110
Tel: (303) 771-3455

CONNECTICUT
12 Lunar Drive
New Haven 06525
Tel: (203) 389-6551
TWX: 710-465-2029

FLORIDA
P.O. Box 24210
2727 N.W. 62nd Street
Ft. Lauderdale 33309
Tel: (305) 973-2600

4428 Emerson Street
Unit 103
Jacksonville 32207
Tel: (904) 725-6333

P.O. Box 13910
6177 Lake Ellenor Dr.
Orlando 32809
Tel: (305) 859-2900

P.O. Box 12826
Suite 5, Bldg. 1
Office Park North
Pensacola 32575
Tel: (904) 476-8422

GEORGIA
P.O. Box 105005
450 Interstate North Parkway
Atlanta 30348
Tel: (404) 955-1500
TWX:810-766-4890

Medical Service Only
***Augusta** 30903
Tel: (404) 736-0592

P.O. Box 2103
1172 N. Davis Drive
Warner Robins 31098
Tel: (912) 922-0449

HAWAII
2875 So. King Street
Honolulu 96826
Tel: (808) 955-4455

ILLINOIS
5201 Tollview Dr.
Rolling Meadows 60008
Tel: (312) 255-9800
TWX: 910-687-2260

INDIANA
7301 North Shadeland Ave.
Indianapolis46250
Tel: (317)842-1000
TWX: 810-260-1797

IOWA
2415 Heinz Road
Iowa City 52240
Tel: (319) 338-9466

KENTUCKY
Medical Only
3901 Atkinson Dr.
Suite 407 Atkinson Square
Louisville 40218
Tel: (502) 456-1573

LOUISIANA
P.O. Box 1449
3229-39 Williams Boulevard
Kenner 70063
Tel: (504) 443-6201

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-9157

2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
23855 Research Drive
Farmington Hills 48024
Tel: (313) 476-6400

724 West Centre Ave.
Kalamazoo 49002
Tel: (606) 323-8362

MINNESOTA
2400 N. Prior Ave.
St. Paul 55113
Tel: (612) 636-0700

MISSISSIPPI
322 N. Mart Plaza
Jackson 39206
Tel: (601) 982-9363

MISSOURI
11131 Colorado Ave.
Kansas City 64137
Tel: (816) 763-8000
TWX: 910-771-2087

1024 Executive Parkway
St. Louis 63141
Tel: (314) 878-0200

NEBRASKA
Medical Only
7171 Mercy Road
Suite 110
Omaha 68106
Tel: (402) 392-0948

NEVADA
***Las Vegas**
Tel: (702) 736-6610

NEW JERSEY
W. 120 Century Rd.
Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

Crystal Brook Professional
Building, Route 35
Eatontown 07724
Tel:(201) 542-1384

NEW MEXICO
P.O. Box 11634
Station E
11300 Lomas Blvd., N.E.
Albuquerque 87123
Tel: (505) 292-1330
TWX: 910-989-1185

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2484
TWX: 910-9983-0550

NEW YORK
6 Automation Lane
Computer Park
Albany 12205
Tel: (518) 458-1550
TWX: 710-444-4961

650 Perinton Hill Office Park
Fairport 14450
Tel: (716) 223-9950
TWX: 510-253-0092

5858 East Molloy Road
Syracuse 13211
Tel: (315) 455-2486

1 Crossways Park West
Woodbury 11797
Tel: (516) 921-0300
TWX: 510-221-2183

NORTH CAROLINA
5605 Roanne Way
Greensboro 27405
Tel: (919) 852-1800

OHIO
Medical/Computer Only
Bldg. 300
1313 E. Kemper Rd.
Cincinnati 45426
Tel: (513) 671-7400

16500 Sprague Road
Cleveland 44130
Tel: (216) 243-7300
TWX: 810-423-9430

330 Progress Rd.
Dayton 45449
Tel: (513) 859-8202

1041 Kingsmill Parkway
Columbus 43229
Tel: (614) 436-1041

OKLAHOMA
P.O. Box 32008
6301 N. Meridan Avenue
Oklahoma City 73112
Tel: (405) 721-0200

4110 S. 100th E. Avenue
Grant Bldg.
Tulsa 74145

OREGON
17890 SW Lower Boones
Ferry Road
Tualatin 97062
Tel: (503) 620-3350

PENNSYLVANIA
111 Zeta Drive
Pittsburgh 15238
Tel: (412) 782-0400

1021 8th Avenue
King of Prussia Industrial Park
King of Prussia 19406
Tel: (215) 265-7000
TWX: 510-660-2670

PUERTO RICO
Hewlett-Packard Inter-Americas
Puerto Rico Branch Office
Calle 272,
Edif. 203 Urg. Country Club
Carolina 00924
Tel: (809) 762-7255
Telex: 345 0514

SOUTH CAROLINA
P.O. Box 6442
6941-0 N. Trenholm Road
Columbia 29260
Tel: (803) 782-6493

TENNESSEE
8914 Kingston Pike
Knoxville 37922
Tel: (615) 523-0522

3027 Vanguard Dr.
Director's Plaza
Memphis 38131
Tel: (901) 346-8370

***Nashville**
Medical Service only
Tel: (615) 244-5448

TEXAS
4171 North Mesa
Suite C110
El Paso 79902
Tel: (915) 533-3555

P.O. Box 1270
201 E. Arapaho Rd.
Richardson 75080
Tel: (214) 231-6101

P.O. Box 42816
10535 Harwin Dr.
Houston 77036
Tel: (713) 776-6400

***Lubbock**
Medical Service only
Tel: (806) 799-4472

205 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-8241

UTAH
2160 South 3270 West Street
Salt Lake City 84119
Tel: (801) 972-4711

VIRGINIA
P.O. Box 12778
No. 7 Koger Exec. Center
Suite 212
Norfolk 23502
Tel: (804) 461-4025/6

P.O. Box 9669
2914 Hungary Springs Road
Richmond 23228
Tel: (804) 285-3431

WASHINGTON
Bellefield Office Pk.
1203-114th Ave. S.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2446

***WEST VIRGINIA**
Medical/Analytical Only
Charleston
Tel: (304) 345-1640

WISCONSIN
9004 West Lincoln Ave.
West Allis 53227
Tel: (414) 541-0550

FOR U.S. AREAS NOT LISTED:
Contact the regional office nearest you: Atlanta, Georgia... North Hollywood, California... Rockville, Maryland...Rolling Meadows, Illinois. Their complete addresses are listed above.

***Service Only**

8/78

DIGITAL VOLTAGE SOURCE
MODEL 6130C
BINARY LOGIC

OPERATING AND SERVICE MANUAL

FOR SERIALS 1312A-00101 AND ABOVE

*For Serials Above 1312A-00101
a change page may be included.

5950-1888

Hewlett-Packard

3

HP Part No. 06130-90004 Printed: October, 1973

TABLE OF CONTENTS

HEWLETT
PACKARD

PRINTED IN U.S.A.